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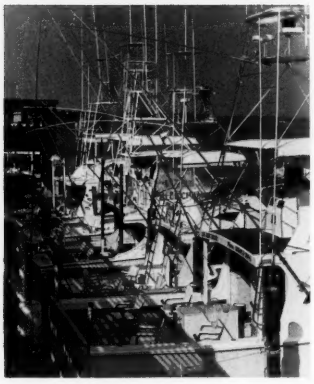

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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A Biological and Economic Analysis of the North Carolina Charter Boat Fishery

CHARLES S. MANOOCH III, LEON E. ABBAS, and JEFFREY L. ROSS

Introduction

The coastal and offshore waters of North Carolina present an ideal fishing situation for marine recreational anglers who search for a variety of pelagic and demersal species. A thriving charter boat[1] fleet of 135 boats has developed over the past 40-50 years and is now harbored at approximately 13 ports along the State's coast.

These charter vessels cater to individual or group needs. They provide full-day and half-day trips to diverse settings ranging from the Gulf Stream, 70 miles offshore, where the azure waters are hundreds of feet deep, to the shallows of sounds and small embayments where marsh grasses encroach on waters only several feet in depth. Fishermen may entice their quarry by trolling lures in open waters, by bottom fishing with squid or fish over artificial and natural reefs, or by casting cut baits in the estuaries.

While the fishing season lasts 8 months (April through November), most of the activity is by trolling in the spring and fall and reflects visitations by transient pelagic fishes attracted to North Carolina's coastal waters by a combination of water temperature, photoperiod, and the availability of food. During most of the summer, boats either fish far offshore for pelagic species or bottom fish over reefs.

Considering the size of the fleet and number of anglers participating annually, it is not particularly surprising that several surveys have been conducted on North Carolina charter boats (Rose and Hassler, 1969; Abbas, 1978; Manooch and Laws, 1979). However, these publications do not allow determination of the magnitude of the catch and effort for all segments of the fishery. Rose and Hassler (1969) reported the catch of only one species, dolphin, *Coryphaena hippurus*; Abbas (1978) conducted a primarily economic survey; and Manooch and Laws (1979) did not include catch and effort for billfishes, sharks, reef fish, or estuarine species in their 1977 survey.

In this paper we present catch and effort data by month and geographical area for all fishing categories and compare results with those obtained in 1977 (Manooch and Laws, 1979). Also, we discuss annual budgets for charter boats by district.

We believe this survey is more accurate than the 1977 study because: 1) project personnel were more experienced with goals and methods of the survey, 2) boat captains and mates were familiar with the project and were more cooperative, and 3) the 1978 survey includes catch and effort for all species and fishing categories based on a stratified sampling design.

[1]A boat for hire on a fixed daily rate regardless of the number of passengers, usually six or fewer.

ABSTRACT—North Carolina's 135 charter boats were surveyed during the 1978 fishing season, April through November, to gather information on catch and effort and profitability of the fishery. The fleet made 9,812 trips during the year: 8,449 trips trolling for pelagic fish, 1,188 bottom fishing for reef fish, 118 bottom fishing in estuaries (primarily for sciaenids), and 57 trips carrying scuba divers.

A total of 1,849,726 pounds (839.3 t) of fish representing 36 species were caught: 1,622,355 pounds (736.1 t) trolling, 220,840 (100.2 t) bottom fishing offshore, and 6,531 (3.0 t) fishing in estuaries. Major species landed while trolling were king mackerel, Scomberomorus cavalla, *bluefish,* Pomatomus saltatrix*; and dolphin,* Coryphaena hippurus. *Black sea bass,* Centropristis striata*; red porgy,* Pagrus pagrus*; and white grunt,* Haemulon plumieri, *were caught most frequently while bottom fishing offshore; flounders,* Paralichthys *spp.; weakfish,* Cynoscion regalis*; and Atlantic croaker,* Micropogon undulatus, *were the major species encountered in the estuaries.*

Species catch and catch per unit effort (number of fish caught/trip, and weight/trip) data are presented by month, geographical area, type of fishing trip, and are compared with results obtained in a similar study in 1977. Economic and related descriptive data are presented by number of trips and district. It is estimated that the fleet grossed $2,409,330 in 1978 based on charter fees alone, an average of $17,847 per boat. Gross incomes for individual boats ranged from about $1,463 to $45,580 for that year.

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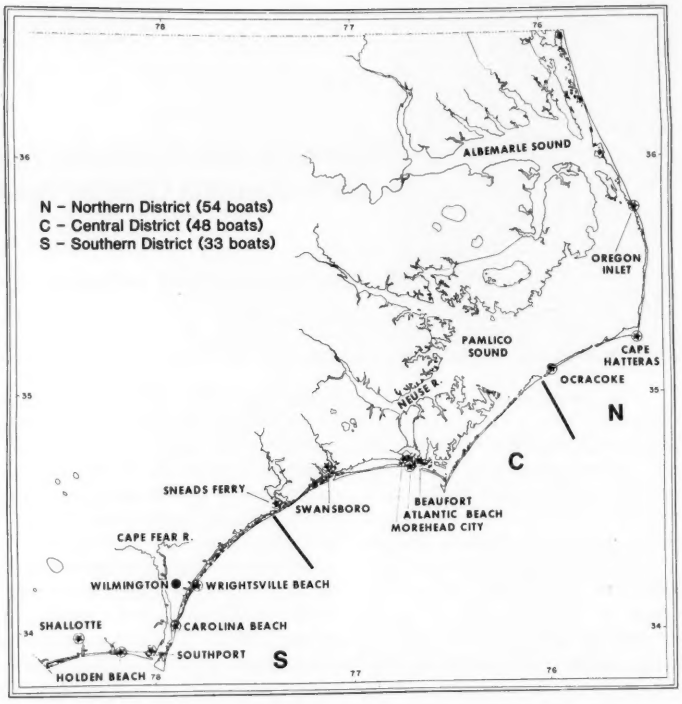
Survey Methods

The charter boat fleet was surveyed in 1978 by personally interviewing boat captains and mates. For the survey, the coastline was partitioned into three geographic strata: Northern district, Oregon Inlet to Ocracoke; central district, Harker's Island and Morehead City-Atlantic Beach to Sneads Ferry; and southern district, south of Sneads Ferry to South Carolina (Fig. 1). Three port samplers, one for each district, identified the charter boat population and made initial contacts with each operator to refamiliarize him with the goals and methods of the survey. Forms for recording daily catches were placed on each boat, filled out by the captain or mate, and picked up by the clerk at least weekly. Some boat crews were contacted daily because they failed to keep daily records but would readily provide data to the clerk for short recall periods (<1 week). Data collected for each boat included number of trips, type of trip, date, fishing locality, and number and estimated weight of each species caught. Clerks periodically sampled landings to obtain estimates of mean weight for each species.



Three North Carolina sampling districts and major charter boat ports.

In general, we followed the methods described by Manooch and Laws (1979) to estimate catch by species and catch per unit effort. We did, however, use a more stratified sampling design to obtain more accurate estimates for each type of fishing activity. The number of trips, standardized to full day, for each boat reporting was obtained, then stratified by district, month, activity (trolling offshore, trolling inshore, bottom fishing offshore, bottom fishing in estuaries, and diving). Catch per unit effort (number of fish/trip) was then calculated for each species for each effort stratum except for the dive trips. Boats known to be fishing, yet not reporting, were usually assigned mean number of trips and mean species catch per unit effort for each activity stratum in which they participated. In some instances port samplers could identify two fishing frequency strata modes: One less active, usually 2-8 trips per month; the other very active, 15-30 trips per month. Nonreporting boats could then be assigned a frequency stratum as well as a type activity stratum, which we believe increased the accuracy of this survey.

For the study of fleet economics, boats were again stratified by district, trip type, and trip frequency (less active and very active). Total receipts were calculated for boats in each district on a cost per trip basis weighted by type of trip and frequency. Variable and fixed costs were subtracted from total receipts giving net return. Net returns were calculated specifically for 1978 by taking Abbas' 1977 data and inflating each cost based upon a factor deduced from the Consumer Price Index (U.S. Department of Labor, 1978).

Results

The cooperation we received from boat captains and mates was excellent in 1978, and better than the previous year. Improvement was mainly attributable to two factors. First, the fishing constituency was more familiar with the project, and their understanding was enhanced by a report on the 1977 survey we furnished them at the beginning of the season. Second, project personnel were more experienced in conducting dockside interviews.

Overall, 83 percent of the boats in the fleet reported to the samplers. Of those fishing, 70 percent reported and provided effort information for 76 percent of the trips. Species catch data were provided for 52 percent of the trips. These excellent response percentages greatly reduced expansion factors required to calculate total catch and catch per unit effort for individual species.

The percentage of boats reporting information to the samplers varied between districts. This variation was due to accessibility of boats within a district

The *Albatross* heads through Hatteras channel.

and the availability of the sampler's time. Very seldom was a sampler denied information. In the northern district, where boats are located primarily at two ports, Oregon Inlet and Hatteras Village, the sampler was able to conduct interviews every other day. Recall periods were for only 2 days. Conversely, boats in the central and southern districts are located at many ports, each with several docking sites. This dispersion tended to diffuse sampler effort, particularly in the central district where the project coordinator served as the field sampler in addition to his supervisory duties.

Charter Boat Activities

North Carolina charter boats made 9,812 trips in 1978: 8,449 trolling, 1,188 bottom fishing for reef fish, 118 fishing in estuaries, and 57 carrying divers. The average boat made 72.7 trips from April through November.

Activities varied substantially between districts and were influenced by access to different types of fishing grounds and by preferences of the clientele. For instance, the Gulf Stream is much closer to the coastline in the northern part of the State than in the central and southern portions. Thus, more boats in the Oregon Inlet and Hatteras area fish in the Gulf Stream for pelagic species than do charter boats elsewhere. On the other hand, bottom fishing is more prevalent in the central and southern districts.

Boats in the northern district made 5,224.5 trips, 53.2 percent of the trips made by the fleet. The average boat in this district made 96.8 trips during the season. One hundred and ten trips were made to fish in the estuaries, and the others trolling: 1,402 inshore for coastal pelagics and 3,712.5 offshore for oceanic pelagic fishes. Effort was greatest in August, followed by July, and then June.

Central district charter boats made 2,784.5 trips: 1,643 trolling inshore, 426.5 trolling offshore, 705 bottom fishing for reef fish, and 10 carrying divers. The average boat made 58.0 trips during the season. Effort was greatest in October, followed by June, and then May.

The 33 boats in the southern district made 1,803 trips; 54.6 per boat for the season. Eight trips were made fishing in estuaries, 1,171 trolling for coastal pelagics, 94 trolling offshore, 483 bottom fishing for reef fish, and 47 dive trips. Most of the effort was in June, followed by May, September, and then October.

Landings

Nearly 2 million pounds (839.3 t) were landed by the charter boat fleet in 1978, representing 36 groups of fish (Table 1). Most catches were identified to species but a few such as those of sharks, groupers, amberjacks, etc., were aggregated at a higher classification level. By weight, the five most important were king mackerel, dolphin, bluefish, yellowfin tuna, and white marlin. Catch data by district and month are discussed under the following separate fishing activity categories.

Trolling Inshore

Fishermen trolling artificial lures in North Carolina's inshore coastal waters caught 17 species of fish in addition to unidentified sharks (Table 2). In all, 143,160 fish weighing 779,769 pounds were landed on 4,216 trips resulting in a catch rate of 34 fish and 185 pounds per trip. This high average catch rate is not surprising when one considers the fact that maximum catches may exceed 200 bluefish and mackerel in 1 day. Bluefish (18.8 fish/trip), king mackerel (10.9), Spanish mackerel (2.0), and little tunny (1.0) were the most frequently caught species. In fact, these four combined constituted 96 percent of the average daily catch by number. Fishes normally occurring offshore (dolphin, wahoo, billfishes, and tunas) were seldom if ever taken while trolling inshore with the minor exception of blackfin tuna landed inshore in the northern region. There, in

Table 1.—Fish caught by North Carolina charter boat anglers in 1978, ranked in order of pounds and indicating major type of fishing category.

Species	Pounds	Fishing category	Species	Pounds	Fishing category
King mackerel, *Scomberomorus cavalla*	446,741	Trolling	Great barracuda, *Sphyraena barracuda*	7,376	Trolling
Dolphin, *Coryphaena hippurus*	274,993	Trolling - offshore	Skipjack tuna, *Euthynnus pelamis*	7,214	Trolling - offshore
Bluefish, *Pomatomus saltatrix*	262,699	Trolling - inshore and Bottom fishing - estuaries	Vermilion snapper, *Rhomboplites aurorubens*	6,468	Bottom fishing - offshore
Yellowfin tuna, *Thunnus albacares*	151,252	Trolling - offshore	Flounders, *Paralichthys*	2,230	Bottom fishing - estuaries
White marlin, *Tetrapturus albidus*	[1]142,844	Trolling - offshore	Cobia, *Rachycentron canadum*	1,910	Trolling
Black sea bass, *Centropristis striata*	141,162	Bottom fishing - offshore	Bluefin tuna, *Thunnus thynnus*	1,667	Trolling - offshore
Blue marlin, *Makaira nigricans*	[1]82,585	Trolling - offshore	Weakfish, *Cynoscion regalis*	1,307	Bottom fishing - estuaries
Wahoo, *Acanthocybium solanderi*	73,603	Trolling - offshore	Gray triggerfish, *Balistes capriscus*	1,192	Bottom fishing - offshore
Amberjacks, *Seriola*	45,433	Trolling and Bottom fishing - offshore	Atlantic croaker, *Micropogon undulatus*	1,004	Bottom fishing - estuaries
Red Porgy, *Pagrus pagrus*	38,066	Bottom fishing - offshore	Red drum, *Sciaenops ocellata*	819	Bottom fishing - estuaries
Blackfin tuna, *Thunnus atlanticus*	37,904	Trolling - offshore	Spot, *Leiostomus xanthurus*	572	Bottom fishing - estuaries
Little tunny, *Euthynnus alletteratus*	37,850	Trolling	Bigeye tuna, *Thunnus obesus*	558	Trolling - offshore
White grunt, *Haemulon plumieri*	16,606	Bottom fishing - offshore	Albacore, *Thunnus alalunga*	428	Trolling - offshore
Sailfish, *Istiophorus platypterus*	[1]16,189	Trolling - offshore	Red snapper, *Lutjanus campechanus*	382	Bottom fishing - offshore
Groupers, *Mycteroperca* and *Epinephelus*	15,632	Bottom fishing - offshore	Longbill spearfish, *Tetrapturus pfluegeri*	370	Trolling - offshore
Spanish mackerel, *Scomberomorus maculatus*	12,397	Trolling - inshore	Frigate mackerel, *Auxis thazard*	326	Trolling - inshore
Sharks, *Carcharhinus*	10,577	Trolling and Bottom fishing - offshore	Crevalle jack, *Caranx hippos*	28	Trolling - inshore
Atlantic bonito, *Sarda sarda*	9,338	Trolling	Bar jack, *Caranx ruber*	4	Trolling - inshore
			Totals	1,849,726	

[1]Includes fish that were officially caught and then released. Weights were expanded for released fish based on mean weight for each species obtained by dockside samples.

Table 2.—Catch and effort for North Carolina charter boats trolling inshore (4,216 trips) and offshore (4,233 trips), 1978.

	Inshore				Offshore			
Species	No. caught	Wt. (lb.)	No./ trip	Wt./ trip	No. caught	Wt. (lb.)	No./ trip	Wt./ trip
King mackerel	46,104	419,511	10.94	99.50	3,207	27,230	0.76	6.43
Spanish mackerel	8,267	12,335	1.96	2.92	16	62	<0.01	0.01
Bluefish	79,117	256,574	18.77	60.86	628	5,526	0.15	1.31
Little tunny	4,381	34,779	1.04	8.25	345	3,071	0.08	0.73
Atlantic bonito	2,242	7,796	0.53	1.85	460	1,542	0.11	0.36
Cobia	54	1,554	0.01	0.37	12	356	<0.01	0.08
Barracuda	384	3,881	0.09	0.92	348	3,495	0.08	0.83
Amberjack	1,948	36,553	0.46	8.67	471	8,492	0.11	2.01
Blackfin tuna	167	1,926	0.04	0.46	3,767	35,978	0.89	8.50
Yellowfin tuna	31	662	0.01	0.16	4,166	150,590	0.98	35.58
Skipjack tuna	6	48	<0.01	0.01	1,097	7,166	0.26	1.69
Bluefin tuna	2	40	<0.01	0.01	31	1,627	<0.01	0.38
Bigeye tuna	–	–	–	–	13	588	<0.01	0.14
Albacore	–	–	–	–	14	428	<0.01	0.10
Frigate mackerel	125	323	0.03	0.08	3	3	<0.01	<0.01
Dolphin	214	1,434	0.05	0.34	52,266	273,559	12.35	64.63
Wahoo	16	496	<0.01	0.12	2,691	73,107	0.64	17.27
Sailfish	–	–	–	–	444	16,189	0.10	3.82
White marlin	–	–	–	–	3,137	142,844	0.74	33.75
Blue marlin	–	–	–	–	358	82,585	0.08	19.51
Longbill spearfish	–	–	–	–	7	370	<0.01	0.09
Bar jack	2	4	<0.01	<0.01	–	–	–	–
Crevalle jack	2	28	<0.01	<0.01	–	–	–	–
Sharks	98	1,825	0.02	0.43	227	7,808	0.05	1.84
Total	143,160	779,769	33.95	184.95	73,708	842,616	17.38	199.06

April and May, the fish occurred just inshore of the Gulf Stream where the water depth ranged from 20 to 30 fathoms.

Coastal pelagics (i.e., king mackerel, Spanish mackerel, bluefish, little tunny, and Atlantic bonito) were generally caught more frequently in the spring and in the fall (Table 3). Catch rates for these species reflect their seasonal migrations. Small bluefish, sought by only a small segment of the fleet, were caught throughout the summer when the large bluefish were not available. November (21.0 fish/trip) followed by April (17.3), August (15.4), and July (12.8) were the best months for this species. Catch per unit effort for king mackerel was best in November, followed by October and May (Table 3).

Combined catch rates for coastal pelagic fishes increased from north to south. In other words, the southern district had a greater catch rate for these fishes than did the northern district, and a slightly higher catch rate than boats fishing out of the central district (Table 4). A larger proportion of the trolling effort in the two southern districts was exerted inshore.

Table 3.—Monthly catch per unit effort (number fish/full-day trip) made by North Carolina charter boats trolling in 1978 (number of trips in parentheses).

Species	April (335)	May (1,032)	June (1,485.5)	July (1,330)	August (1,442)	September (1,191)	October (1,203.5)	November (430)
King mackerel	7.20	12.11	4.14	1.21	0.74	2.82	15.92	7.11
Spanish mackerel	<0.01	0.07	0.73	0.32	2.91	2.00	0.11	–
Bluefish	17.27	7.06	7.62	12.81	15.37	2.30	3.64	21.03
Little tunny	2.78	0.58	0.15	0.18	0.22	0.54	1.17	0.82
Atlantic bonito	0.78	0.69	0.80	0.05	0.07	0.09	0.21	<0.01
Frigate mackerel	0.16	0.07	<0.01	–	–	–	–	–
Cobia	–	<0.01	0.02	0.01	<0.01	0.01	<0.01	–
Barracuda	–	0.04	0.09	0.19	0.13	0.09	0.01	–
Amberjack	0.44	0.19	0.28	0.32	0.16	0.44	0.32	0.20
Blackfin tuna	0.39	1.12	0.70	0.22	0.26	0.66	0.14	0.02
Yellowfin tuna	0.12	0.27	0.29	2.03	0.16	0.20	0.23	–
Skipjack tuna	–	–	0.07	0.30	0.23	0.23	0.01	–
Bluefin tuna	–	<0.01	0.02	–	–	–	–	–
Bigeye tuna	–	–	–	0.01	–	–	–	–
Albacore	–	–	–	–	–	0.01	–	–
Dolphin	0.54	2.78	14.53	8.93	7.27	4.34	0.26	–
Wahoo	0.05	0.13	0.11	0.31	0.64	0.79	0.10	<0.01
Sailfish	–	<0.01	0.01	0.06	0.17	0.09	0.01	–
White marlin	0.01	0.02	0.11	0.52	0.59	1.13	0.04	–
Blue marlin	–	0.04	0.06	0.09	0.05	0.02	<0.01	–
Longbill spearfish	–	<0.01	–	–	<0.01	–	–	–
Bar jack	–	<0.01	–	–	–	–	–	–
Crevalle jack	–	–	–	–	–	–	<0.01	–
Sharks	–	0.02	0.05	0.05	0.01	0.07	0.05	0.01
Total	29.74	25.19	29.78	27.61	28.98	15.83	22.22	29.19

Table 4.—Catch and effort for North Carolina charter boats in 1978, by district. Number of trolling trips were: Northern district, 5,114.5 (1,402 inshore and 3,712 offshore); central district, 2,069.5 (1,643 inshore and 426.5 offshore); and southern district, 1,265 (1,171 inshore and 94 offshore).

	Northern district				Central district				Southern district			
Species	No. caught	Weight (lb.)	No./ trip	Wt./ trip	No. caught	Wt. (lb.)	No./ trip	Wt./ trip	No. caught	Wt. (lb.)	No./ trip	Wt./ trip
King mackerel	14,839	147,515	2.90	28.84	20,559	183,496	9.93	88.67	13,913	115,730	11.00	91.49
Spanish mackerel	176	411	0.03	0.08	5,359	7,426	2.59	3.59	2,748	4,560	2.17	3.60
Bluefish	59,746	147,893	11.68	28.92	12,837	61,489	6.20	29.71	7,162	52,718	5.66	41.67
Little tunny	1,356	11,849	0.27	2.32	2,617	20,270	1.26	9.79	753	5,731	0.60	4.53
Atlantic bonito	830	2,693	0.16	0.53	533	1,589	0.26	0.77	1,339	5,056	1.06	4.00
Cobia	25	672	<0.01	0.13	33	1,046	0.02	0.51	8	192	0.01	0.15
Barracuda	120	1,081	0.02	0.21	282	2,907	0.14	1.40	330	3,388	0.26	2.68
Amberjack	296	5,338	0.06	1.04	1,537	26,653	0.74	12.88	586	13,054	0.46	10.32
Blackfin tuna	3,660	34,685	0.72	6.78	151	1,607	0.07	0.78	123	1,612	0.10	1.27
Yellowfin tuna	4,122	148,905	0.81	29.11	32	970	0.02	0.47	43	1,377	0.03	1.09
Skipjack tuna	1,055	6,930	0.21	1.35	46	276	0.02	0.13	2	8	<0.01	0.01
Bluefin tuna	32	1,657	<0.01	0.32					1	10	<0.01	0.01
Albacore	14	428	<0.01	0.08								
Bigeye tuna	13	558	<0.01	0.11								
Dolphin	48,864	253,744	9.55	49.61	2,752	15,191	1.33	7.34	864	6,058	0.68	4.79
Wahoo	2,263	60,761	0.44	11.88	377	10,791	0.18	5.21	67	2,051	0.05	1.62
Sailfish	426	15,478	0.08	3.03	15	600	<0.01	0.29	3	111	<0.01	0.09
White Marlin	3,126	142,383	0.61	27.84	10	426	<0.01	0.21	1	35	<0.01	0.03
Blue Marlin	345	78,799	0.07	15.41	6	1,614	<0.01	0.78	7	2,172	0.01	1.72
Longbill spearfish	7	370	<0.01	0.07								
Bar jack	2	4	<0.01	<0.01								
Crevalle jack	2	28	<0.01	<0.01								
Frigate mackerel	3	3	<0.01	<0.01	113	283	0.05	0.14	12	40	0.01	0.03
Sharks	194	7,135	0.04	1.40	65	1,001	0.03	0.48	66	1,497	0.05	1.18
Total	141,516	1,069,320	27.67	209.08	47,324	337,635	22.87	163.15	28,028	215,400	22.16	170.26

Trolling Offshore

Boats trolling offshore waters landed 21 species of fish in addition to unidentified sharks (Table 2). Fishermen made 4,233 offshore trips, caught 73,708 fish weighing 842,616 pounds, resulting in a catch rate of 17.4 fish/trip and 199.1 pounds/trip. As expected, the average fish was much larger than that taken inshore. Dolphin (12.3 fish/trip) was far and away the dominant species taken, followed by yellowfin tuna (0.98) and blackfin tuna (0.89). By number, dolphin represented 71 percent of the daily offshore catch, and the three combined, dolphin, yellowfin, and blackfin tunas, comprised 82 percent. With the exception of 3,207 king mackerel (only 6.5 percent of the total king mackerel catch), coastal pelagics were very infrequently caught offshore (Table 2).

Oceanic pelagic fishes generally occurred more frequently in summer and early fall landings. Highest monthly average catch rates (fish/trip) for selected species were: Dolphin, June (14.5); yellowfin tuna, July (2.0); blackfin tuna, May (1.1); wahoo, September (0.8); and white marlin, September (1.1) (Table 3).

Trolling offshore was far more productive in terms of catch per unit effort in the northern district than in either of the other two areas (Table 4). Not only is the Gulf Stream closer to Hatteras and Oregon Inlet, resulting in a higher proportion of offshore trips, but evidently a combination of physical factors, such as currents, temperature, and bottom topography, makes the northern district far more attractive to oceanic pelagic species. Approximately 93 percent of the dolphin, 96 percent of the yellowfin and blackfin tunas, 84 percent of the wahoo, and over 95 percent of the billfishes were caught in this area of the State. Oceanic pelagic fishes landed in tournaments by nonchartered boats were not included in this survey.

Inshore and offshore trolling trips combined produced an average 25.7 fish and 192.0 pounds/trip (Table 5). Mean weight for each species per trip is also included in Table 5.

Table 5.—North Carolina charter boat landings made on 8,449 trolling trips, 1978 (4,216 trips inshore, 4,233 trips offshore).

Species	No. caught	Wt. (lb)	No./ trip	Wt. (trip)
King mackerel	49,311	446,741	5.84	52.87
Spanish mackerel	8,283	12,397	0.98	1.47
Bluefish	79,745	262,100	9.44	31.02
Little tunny	4,726	37,850	0.56	4.48
Atlantic bonito	2,702	9,338	0.32	1.10
Cobia	66	1,910	<0.01	0.23
Barracuda	732	7,376	0.09	0.87
Amberjack	2,419	45,045	0.29	5.33
Blackfin tuna	3,934	37,904	0.47	4.49
Yellowfin tuna	4,197	151,252	0.50	17.90
Skipjack tuna	1,103	7,214	0.13	0.85
Bluefin tuna	33	1,667	<0.01	0.20
Bigeye tuna	13	558	<0.01	0.07
Albacore	14	428	<0.01	0.05
Frigate mackerel	128	326	0.02	0.04
Dolphin	52,480	274,993	6.21	32.55
Wahoo	2,707	73,603	0.32	8.71
Sailfish	444	16,189	0.05	1.92
White marlin	3,137	142,844	0.37	16.91
Blue marlin	358	82,585	0.04	9.77
Longbill spearfish	7	370	<0.01	0.04
Bar jack	2	4	<0.01	<0.01
Crevalle jack	2	28	<0.01	<0.01
Sharks	325	9,633	0.03	1.14
Total	216,868	1,622,355	25.66	192.01

A mate in Morehead City, N.C., washes down part of a day's catch of large bluefish.

Bottom Fishing for Reef Fishes

Boats fishing offshore for reef fish occurred only in the central and southern districts. There, 1,188 trips were made producing 215,498 fish weighing 220,840 pounds (Table 6). The average trip yielded 181.4 fish weighing 185.9 pounds. The bulk of the catch was black sea bass (75 percent by number and 64 percent by weight). Other than black sea bass, red porgy, white grunt, vermilion snapper, and groupers were caught frequently. Fishing for reef fish was slightly better in the southern district (184.4 fish/trip compared with 178.3 for the central district). The catch rates for red porgy, white grunt, and grouper were higher in the southern area, whereas catch rates for black sea bass and vermilion snapper were higher for the central district (Table 6).

We do not present data on the landings of the nonmigrating reef fishes by month. We observed, however, that more effort was exerted during the summer months when coastal pelagic fishes were not readily available and suggest that catches were therefore higher in summer.

Anglers display catch of tunas, dolphin, wahoo, king mackerel, and sharks.

Fishing in Estuaries

Very few charter boats made trips to fish in estuaries. Only 118 trips were reported (Table 7). There, fishermen caught 5,809 fish, mainly sciaenids and flounders, which weighed 6,531 pounds. The average trip produced 49.2 fish, which weighed 55.3 pounds. The most frequently caught fish were Atlantic croaker, weakfish, flounders, and bluefish. No data are presented on catches of these fish by month.

Profitability of the Fleet

Gross income (total revenue) based on charter fees was calculated for the

Part of Oregon Inlet charter boat fleet.

Table 6.—Catch and effort for central district boats (705 trips) and southern district boats (483 trips) bottom fishing offshore, 1978.

Species	Central				Southern				Total			
	No. caught	Wt. (lb.)	No./trip	Wt./trip	No. caught	Wt. (lb.)	No./trip	Wt./trip	No. caught	Wt. (lb.)	No./trip	Wt./trip
Black sea bass	101,419	91,244	143.86	129.42	60,808	49,918	125.90	103.35	162,227	141,162	136.55	118.82
Red porgy	13,848	17,238	19.64	24.45	17,025	20,828	35.25	43.12	30,873	38,066	25.99	32.04
White grunt	5,091	5,869	7.22	8.32	9,208	10,737	19.06	22.23	14,299	16,606	12.04	13.98
Vermilion snapper	5,091	5,040	7.52	7.15	946	1,428	1.96	2.96	6,468	6,468	5.26	5.44
Red snapper	28	168	0.04	0.24	33	214	0.07	0.44	61	382	0.05	0.32
Grouper	323	2,273	0.46	3.22	969	13,359	2.01	27.66	1,292	15,632	1.09	13.16
Gray triggerfish	312	964	0.44	1.37	58	228	0.12	0.47	370	1,192	0.31	1.00
Amberjacks	5	63	0.01	0.09	15	325	0.03	0.67	20	388	0.02	0.33
Sharks	107	944	0.15	1.34	—	—	—	—	107	944	0.09	0.79
Total	126,436	123,803	179.34	175.60	89,062	97,037	184.40	200.90	215,498	220,840	181.40	185.88

Table 7.—North Carolina charter boat catch and effort for bottom fishing in estuaries, 1978.

Species	Number	Weight	Number per trip
Atlantic croaker	1,434	1,004	12.15
Spot	953	572	8.08
Red drum	273	819	2.31
Weakfish	1,089	1,307	9.23
Flounders	1,062	2,230	9.00
Bluefish	998	599	8.46
Total	5,809	6,531	49.23
Trips	118		
Pounds/trip		55.35	

Table 8.—Average and total revenue by district for North Carolina charter vessels, 1978.

Item	Northern district	Central district	Southern district	Total
No. of vessels	54	48	33	135
Average total revenue	25,536	13,052	12,239	17,847
Gross revenue	$1,378,942	$626,513	$403,875	$2,409,330

entire fleet and for each district (Table 8). Fees for a full-day trip ranged from $275 for fishing the Gulf Stream in the northern district, to $175 for bottom fishing in estuaries in the southern district. A total of $2,409,330 was grossed by the fleet in 1978 ($17,847/boat).

The estimated market values of vessels operating during the 1978 fishing season are presented in Table 9. Vessels in each district are separated into two classes based upon number of trips. The mean market values range from $20,583 to $48,995 with both of these extremes occurring in the northern district. Mean boat lengths vary little between district or frequency of operation class.

Correlation coefficients were obtained to determine the relationship between number of trips and boat length and between trips and boat value. Boat size and frequency of operation are positively correlated as are vessel market value and frequency of operation. Age of vessel and number of trips are negatively correlated. As one would suspect, newer and larger vessels generally have an advantage in producing revenue. Eighty-six percent of North Carolina charter boats are constructed of wood, 8 percent of fiberglass, and 6 percent of wood and fiberglass combined.

Total costs are a sum of variable and fixed costs. Variable costs result from vessel operation and increase with the number of trips. Fixed costs, sometimes called overhead, occur whether the vessel is tied to the dock or fishing. Fixed costs remain constant regardless of fishing activity.

Costs and returns for 1978 are shown in Table 10. The revenue data are from 1978 and the cost data are adjusted from 1977 using appropriate consumer price indices. Total revenues varied by district.

For instance, the high frequency category, northern district vessels received 466 percent greater revenues than those from the central district, lower frequency category.

Total variable cost was also substantially higher for vessels in the high frequency, northern district category, $17,723 versus $4,868 and $4,999 for lower frequency class vessels in the central and southern districts, respectively. This difference is explained by the greater number of trips, 46 more than the next highest category. Oil and fuel, mate services, and maintenance—the three largest contributors—accounted for 90 percent to 96 percent of variable costs. In all locations and operation classes, except the high frequency category of the northern district, maintenance was the highest percentage of variable costs.

Fixed costs do not change with the number of trips; therefore, more trips reduce the fixed cost per trip (i.e., spread the overhead). Fixed costs per trip are lowest for high frequency, northern district vessels at $32.48 and highest for lower frequency, southern district vessels at $114.41. Depreciation, the largest contributor, accounted for 29-57 percent of fixed costs. The highest depreciation was in the high frequency, northern district where vessels were newest ($\bar{x}$ = 10 years) and most valuable. Total costs were lowest for low frequency vessels. The highest total cost figure ($22,043) was from the upper mode northern district.

Net return to labor, capital, and management varied considerably. The highest net return was to vessels in the high frequency northern district ($13,258) and the lowest was to vessels in the low frequency, southern district (−$912), a loss. Vessels in the low frequency, central district incurred an average loss of $237.

Table 9.—North Carolina boat characteristics by district and number of trips, 1978.

	Northern district: Avg. no. of trips[1]		Central district: Avg. no. of trips[1]		Southern district: Avg. no. of trips	
Item	68	133	34	87	37	71
Est. mean market value of boat ($)	20,583	48,995	30,127	36,526	27,501	33,642
SD	24,340	39,636	28,208	22,520	23,056	19,837
Minimum value	2,000	15,000	6,000	4,000	3,000	12,000
Maximum value	90,000	150,000	90,000	100,000	60,000	65,000
Mean age of boat (years)	25	10	18	12	14	20
SD	10.8	8.4	8.8	10.2	11.3	7.4
Minimum value	new	new	new	new	new	6
Maximum value	44	26	30	38	30	25
Mean length of boat (feet)	37	45	42	44	38	45
SD	6.9	5.6	5.4	5.4	5.4	5.0
Minimum value	31	36	35	30	29	38
Maximum value	53	53	52	50	44	52

[1]Distribution of trips is bimodal; the mean for each mode is shown.

Table 10.—Annual costs and returns for North Carolina charter vessels by average number of trips and district, 1978.

	Northern district: Avg. no. of trips[1]				Central district: Avg. no. of trips[1]				Southern district: Avg. no. of trips[1]			
Item	68		133		34		87		37		71	
Total revenue[2]	$17,724		$35,301		$7,579		$19,521		$8,320		$15,926	
Costs												
Variable												
Oil and fuel	2,629	26%	6,384	36%	1,050	22%	2,606	26%	981	19%	2,758	31%
Booking services	137	01	287	02	68	01	293	03	0	0	0	0
Bait	646	06	1,047	06	158	03	378	04	113	02	76	1
Ice	199	02	404	02	111	02	215	01	99	02	232	03
Mate	2,541	25	4,280	24	1,276	26	3,356	33	1,130	22	2,184	25
Maintenance	4,036	40	5,321	30	2,205	45	3,337	33	2,676	55	3,549	40
Total	$10,188	100%	$17,723	100%	$4,868	99%	$10,185	100%	$4,999	100%	$ 8,799	100%
Fixed												
Insurance	$ 422	17%	$ 733	17%	$ 681	23%	$ 1,478	31%	$1,495	35%	$ 1,468	34%
Advertising	206	08	190	04	96	03	426	09	342	09	280	07
Dockage	340	14	365	08	391	13	651	13	713	17	743	17
Depreciation	1,130	45	2,481	57	1,598	54	2,009	42	1,565	37	1,269	29
Utilities	214	08	329	08	77	03	123	02	59	01	245	06
Miscellaneous	206	08	222	05	105	04	144	03	59	01	298	07
Total	$ 2,518	100%	$ 4,320	99%	$2,948	100%	$4,831	100%	$4,233	100%	$ 4,303	100%
Total costs	$12,706		$22,043		$7,816		$15,016		$9,232		$13,095	
Net return to labor, capital, and management	$ 5,018		$13,258		-$ 237		$ 4,505		-$ 912		$ 2,831	

[1]Distribution of trips is bimodal; the mean for each mode is shown.
[2]Revenue data is from 1978; cost data is from 1977 adjusted by appropriate categories of the CPI.

Discussion

Some of the results obtained in this survey may be compared directly with those from the 1977 survey (Manooch and Laws, 1979). Excluding billfish and sharks, landings made in 1978 by boats trolling were 1,370,734 pounds (162.2 pounds and 25.2 fish per trip), and in 1977, 1,568,108 pounds (197.6 pounds and 30.0 fish per trip). The average boat made 62.5 trips trolling in 1977 and 63.1 trolling trips in 1978. While the catches and catch rates for all species combined were similar for the 2 years, there were major differences in the landings for individual species. For instance, catches of king and Spanish mackerels, little tunny, and blackfin tuna were down in 1978, while catches of bluefish, yellowfin tuna, and dolphin were up. Relative to the previously listed species, wahoo were caught with equal frequency both years (0.39 fish per trip in 1977 and 0.32 fish per trip in 1978).

Two other studies, each targeted at a single species, provide estimates of the North Carolina charter boat landings for dolphin in 1961 and 1962 (Rose and Hassler, 1969) and wahoo for 1964 to 1972 (Hogarth, 1976). Charter boats landed 35,050 dolphin in 1961 and 68,007 in 1962. Since effort had essentially doubled in 1962, they estimated that the average charter boat landed approximately 700 dolphin. The total landings for dolphin in 1978 were 52,480 fish and 274,993 pounds. While the average boat in 1978 landed only 389 fish, the bulk of

A white marlin is brought on board by mate John Bayliss.

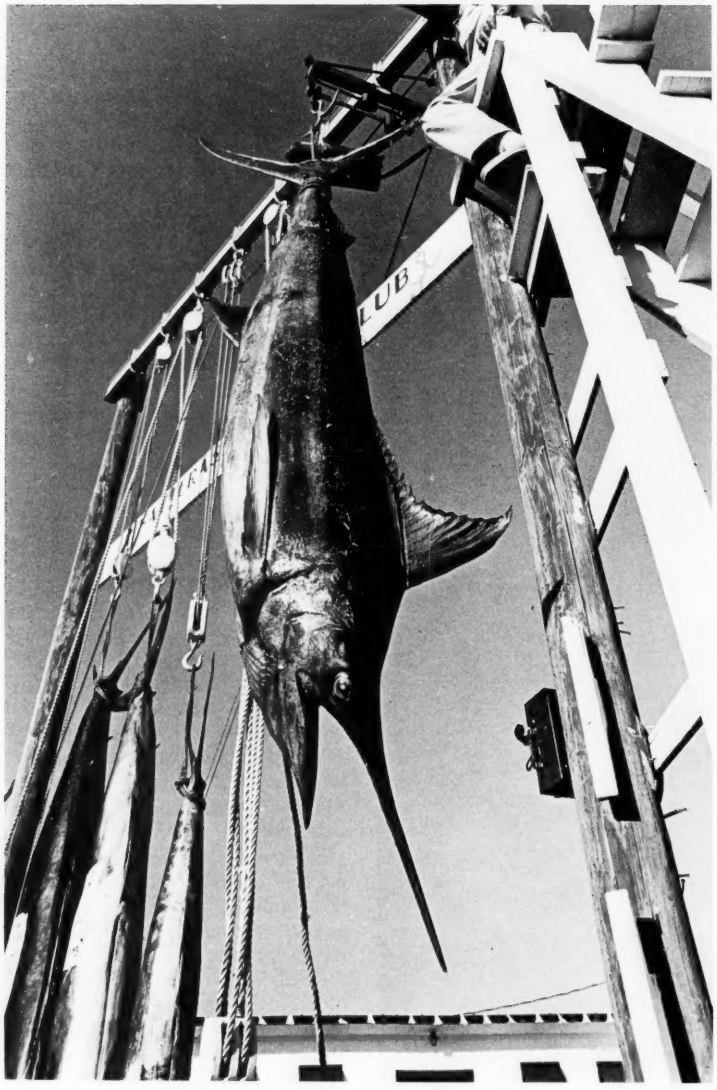
the catch for this species was made in the northern district where the average boat there caught 922 dolphin for the season. Boats trolling offshore out of Hatteras and Oregon Inlet caught an average of 17.8 dolphin per trip in 1961 (Rose and Hassler, 1969). Charter boats fishing the same areas in 1978 caught an average of 13.1 dolphin per offshore trip. The effort has almost tripled: 1,383 trips in 1961 and 3,712.5 trips in 1978.

The catches of wahoo have apparently increased over the years. Hogarth (1976) reported landings at Oregon Inlet and Hatteras from 1964 to 1972 and found an average 0.23 wahoo caught per offshore trip. The last year of his study, the catch rate was 0.37 fish. For the same areas in 1978 the average boat caught 0.61 wahoo per offshore trolling trip.

Our reported "landings" of billfish (3,939) may seem inflated even though a large percentage were officially caught and then released at sea. Abbas' survey provides the only available data that may permit us to evaluate the magnitude of the billfish landings. His total landing weights for each species were divided by the mean weights we obtained by dockside sampling (Manooch and Ross, 1979) to estimate the number of fish brought to the dock. The estimated 1977 billfish catch was 1,680 fish and the 1978 catch was 1,500.

Bottom fishing for reef fish is becoming more common from charter boats. Boats in 1977 made 980 trips, 7.7 per boat, and landed 172,189 pounds, or 175.7 pounds per trip. In 1978, 1,188 trips were made, an average of 8.8 per boat, resulting in a catch of 220,841 pounds (181.4 pounds per trip). As fishing for coastal pelagics became less productive in 1978, more of the central and southern districts' boats pursued this form of angling. This trend will probably continue if coastal pelagic species remain scarce.

Substantial variation exists between the economic regimes of vessel operations in different geographical districts and activity categories. The average return to vessels in the more active category, northern district is much higher than other groups. The vessels in this category are newer and have higher estimated market values. While variable costs rise as trips increase, boats in the more frequently operating class, northern district had many more trips than boats in other districts and classes, resulting in much higher revenues and substantially higher net returns. We see two possible reasons why net returns are substantially greater for northern district charter boats. First, net returns include a return to capital. The average northern district vessel in the high frequency of trip category is $48,995 (Table 9), which is $12,469 greater than the next highest category—high frequency vessels, central region. Addi-



A rack of blue marlin at the Hatteras Marlin Club.

tionally, there is a positive correlation between boat value and frequency of trips. This positive correlation may be explained, in part, by newness of the vessels (Table 9). "Newness" may be interpreted by potential customers as meaning safety, comfort, speed, and fishing effectiveness, thereby resulting in a shift in demand for trips on these vessels and therefore a short-term increase in revenue.

The second reason for greater profitability is related to geographical location. The demand for charter boat services is derived from the demand for offshore fishing. Port location has a large influence on the number of trips the boat captain may expect to charter during a season. In the northern district, vessels have the advantage of proximity of the Gulf Stream. Anglers can fish for large oceanic pelagic fishes within 2 hours after leaving the dock. The proximity of the Gulf Stream to the port results in short runs to fish and correspondingly longer fishing time. Another advantage to the northern district fleet is that tourists are concentrated along the very narrow strip of land, the Outer Banks, with charter boat facilities easily available.

Additionally, there are few private boats in the northern district capable of safely fishing in the Gulf Stream, thereby less competition for the charter fleet. The result is once again a tendency to shift the demand function to the right and also to be relatively more inelastic due to the uniqueness to the area. The combination of more trips and higher prices results in more revenue. The relatively large number of trips results in lower costs per trip, i.e., spreading the overhead, thereby increasing net profit.

Boats farther to the south have proportionally longer runs to the Gulf Stream, consume more fuel, and offer shorter fishing times. Therefore, these vessels tend to offer a wider variety of inshore angling, in addition to occasional diving trips. However, fishing inshore and in protected waters is not as attractive to many charter boat customers as is Gulf Stream fishing. The nearshore trips can be made easily and inexpensively in smaller, privately owned craft resulting in less demand for charter services.

The difficulties one encounters attempting to analyze marine recreational catch data for only a short period of time (in our case 2 years) are numerous. While total pounds landed and total catch per unit effort have varied little, fluctuations in catch rate for individual species may be great. The highly migratory pelagic fishes are good examples. Could we suggest that because North Carolina charter boat landings of mackerels were down in 1978 that the populations were at lower levels of abundance? Surely not. Perhaps fishermen in other

Deep sea action is shown in the faces of this New York family reeling in a white marlin.

areas experienced better than average catches for those species during the same time interval, and for some unexplainable reason, mackerels did not visit the coastal waters of North Carolina as they had the previous year. Overfishing maybe, but maybe not. The importance of a national or regional marine recreational fisheries survey is underscored. The North Carolina charter boat surveys have provided valuable information. Their intensity should guarantee accuracy, thus they can serve to test the reliability of regional surveys. And, our surveys have contributed valuable information to the State of North Carolina where the charter boat fleet is a valuable industry that grosses millions of dollars annually and furnishes recreational enjoyment for thousands of people.

Acknowledgments

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Paying-Passenger Recreational Fisheries of the Florida Gulf Coast and Keys

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ABSTRACT—Four types of paying-passenger recreational fisheries operate on the Florida Gulf coast and in the Florida Keys: Offshore charter boat, inshore-offshore charter boat, guide boat, and head boat. An estimated 604 captains were active in the fisheries in 1977. Target species differ with fishery type and region of operation. Declining catches (catch-per-unit-effort) and increased operating costs, particularly for fuel, are major problems of these fisheries, according to the captains. In those fisheries where information is available, the number of operations has increased in the past 15 years in the Florida Keys, whereas the number has decreased greatly on the west Florida coast and decreased slightly on the northwest Florida coast.

Introduction

The paying-passenger recreational fisheries are major Florida fisheries in terms of total direct income and contribute significantly to Florida's tourist-based economy. The economic importance of these fisheries has been difficult to evaluate because of a lack of information on the total number of participants and level of activities. This information is not readily available due to the dispersed nature of the fisheries, lack of organizations representing them (except in a few locations), and poor state records.

This report provides an overview of the paying-passenger fisheries on the Florida Gulf coast and Keys (Fig. 1) based on a survey conducted in 1977 and 1978. The report discusses types of fisheries, centers of activity, numbers of participants, species dependence, and major problems or concerns. Estimates of the number of participants and species dependence of the fisheries from our survey are compared with Moe's (1963) figures for the early 1960's.

Methods

List Compilation

A list of names and addresses of potentially active operations was developed from: 1) The computerized list of commercial licenses (charter-boat category) issued in west coast counties by the Florida Department of Natural Resources in 1975-76; 2) local occupational license lists and/or fishing permit lists, where available; 3) the yellow pages of the telephone directories of coastal communities, under the headings "fishing information," "fishing parties," and "boats-rental and charter," and 4) visits to all major established commercial docks.

Use of several sources was necessary because none would have been sufficient if used alone. Active operators were difficult to determine from state boat registrations because the most recent state list available was 3 years old and included operators that were no longer

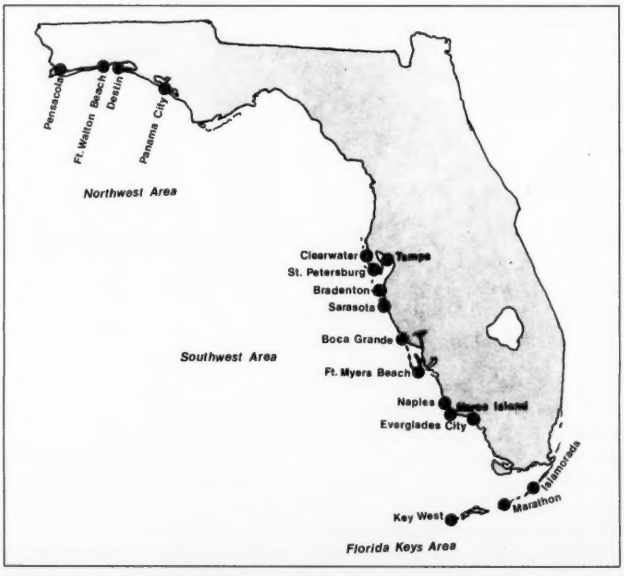

Figure 1.—Areas and activity centers of the Florida Gulf of Mexico paying-passenger recreational fisheries.

active. Furthermore, a number of persons who are not in the business habitually register their boats as commercial charter in Florida. The dock visit was the most important source of information in compiling the list of active operators and served as an advance contact to increase the response rate on the mailing questionnaire. During dock visits the survey team introduced themselves to the operators and explained the purposes of the study. The telephone directory listing was a complementary source of information, because operators at major docks often were not listed in the telephone directory, whereas operators not connected with a major dock usually were listed.

Names on the state boat registration list (owners) and names obtained from telephone directories or dock signs (captains) could not be connected when operators were not owners; therefore, some operations may have been listed more than once. The hired captains of additional boats owned by an active captain usually were not advertised and may have been left off the list. These problems could have been totally resolved only by visiting all the active boats in an area or by talking with a local person who knew all the active operators in an area, which was not possible for all locations.

Owner-operators receiving the questionnaire were asked to identify their type of operation, their main port, the species for which they fished each season, the percent of total effort each season directed at each species, and their major problems or concerns.

Questionnaire Distribution

Distribution of the questionnaires in different regions was determined by the nature of the fishery, different receptivity to the study, and special opportunities arising in each area. Most of the questionnaires were mailed, but survey personnel or local representatives of the industry made hand-deliveries in some locations. All mailed questionnaires not returned by respondents were followed by a second mailing of the same questionnaire within a few weeks. A special short form of the questionnaire from which economic questions were deleted was distributed by the Islamorada Guide Boat Association in lieu of mailing the full questionnaire to Islamorada guides.

Offshore charter-boat action at Whale Harbor, Islamorada, Fla.

Results

Types of Operators

Four distinct types of operators were found in the study area: 1) The offshore charter boat; 2) the inshore-offshore charter boat, which fishes bays and backcountry as well as offshore; 3) the guide boat, which specializes in backcountry fishing; and 4) the head boat, distinguished by the larger number of passengers and the custom of charging on a per-customer (or head) rather than per-boat basis. Most head boats fish offshore, but a few of the smaller ones fish inshore.

Activity Centers

Activity for offshore charter boats and head boats in northwest Florida was centered at Destin and Panama City. In west Florida the main offshore charter-boat centers were Clearwater, Ft. Myers Beach, Naples, and Marco Island. Inshore-offshore boats operated from Boca Grande and Tampa. Guide-boat centers were Sanibel-Captiva, Marco Island, and Everglades City. Most ports had at least one head boat.

The major ports for offshore charter-boat activity in the Florida Keys were Islamorada, Marathon, and Key West. Guide boats worked out of Key Largo, Islamorada, Marathon, and Big Pine Key. Inshore-offshore charter boats were located primarily in Key West. Head boats were found in Key Largo, Islamorada, Marathon, and Key West.

Boat Distribution

Regional differences were found in the distribution of boats between major public or commercial docks, small commercial docks, and private docking facilities. Boats were concentrated at a few major facilities in northwest Florida. Along the west coast, boats were located at a number of relatively small commercial docks, but the sizeable portion of listed names that could not be found at the commercial docks suggests that small private docks may also have

been important. There were no public or commercial docking facilities in Boca Grande, despite the relatively large number of boats in operation there. Guide boats on Sanibel-Captiva and Marco Islands usually were associated with a commercial or hotel dock. Most of the charter boats in the Florida Keys were concentrated at large public or commercial docking facilities. A number of guide boats also were found at these docks; but, in southwest Florida and in the Keys, many guide boats small enough to be trailered were not associated with any dock.

Percent Returns and Estimates of Total Activity

Questionnaires were sent to 770 captains. Addresses were inadequate for delivery of 59 (7.3 percent) questionnaires, which were returned by the post office, leaving a total of 711 presumably delivered. Of these, 16.15 percent responded to the first mailing. The second mailing increased the response rate to 31.32 percent. Of the respondents, 21.52 percent informed us that they were not now (14.34 percent) or never had been (5.83 percent) charter-boat captains or that the addressees were deceased (1.35 percent). The 175 "actual" returns came from 91 offshore charter-boat captains, 5 inshore-offshore charter-boat captains, 60 guide-boat captains, and 19 head-boat captains (Table 1). A breakdown by area of inadequate addresses on the original mailing list and inactive persons in responses is given in Table 2.

Assuming that the percent of inactives in the nonrespondents was estimated to be the same as that in the respondents, the estimated total active operators in the study area was 604 (770 × 0.2152).

The corrected list and other information obtained by dock visits were used to estimate the number of operators in each category and their distributions by area. These estimates (Table 3) had a higher proportion of offshore charter-boat operators relative to guides than the returns (Table 4). This difference probably was due to an inability to distinguish guides from offshore charter-boat captains on the list for west Florida. All the names on the list were assumed to be offshore charter-boat captains unless known to be otherwise.

Return rate (percent) was calculated as the number of actual returns divided by the estimated total number of operating captains that, to the best of our knowledge, received the questionnaire. Estimated return rate was 31.25 percent (100 × 175/560). Active recipients (504) were estimated by subtracting the number of insufficient addresses on the original list from the number of estimated actives.

Estimated return rates by locality and type of operation are given in Table 5. The high return rate from guide boats in the Upper Keys probably is due to the fact that the most of the operators in that area received short forms distributed by the guide-boat association.

Species Dependence and Percent Fishing Effort

Captains were asked to list the species for which they fished during each season and the percent of their fishing effort expended on each species. Based on responses to the questionnaire, a seasonal mean percent fishing effort was computed for target species and species-groups

Table 1.—Tally of responses to the mailing questionnaire by segments of the industry.

Type of operator	Total sent	Total nondeliverable	Response to first mailing	Response to second mailing	Total response	Never were charter captains	Not now charter captains	Deceased	Total "good" returns
Head boat	55	2	15	6	21	0	2	0	19
Guide boat	114	6	31	32	63	0	3	0	60
Offshore charter	585	50	66	68	134	13	27	3	91
Inshore/offshore charter	16	0	3	2	5	0	0	0	5
Total	770	58	115	108	223	13	32	3	175

Table 2.—Percent inadequate addresses on original mailing list and percent inactive persons in responses.

Area	Total orig. mailing list	Inadequate addresses No.	Inadequate addresses %	Total responses	Inactive operators No.	Inactive operators %
N.W. coast	122	17	13.93	29	1	3.45
W. coast	280	22	7.86	77	21	27.27
Keys	368	19	5.16	117	26	22.22

Table 3.—Estimated distribution of types of operators among regions.

Type of operator	N.W. Florida	W. Florida	Florida Keys	Total
Offshore charter	138	99	154	391
Inshore/offshore charter	0	9	8	17
Guide boat	0	46	83	129
Head boat	23	22	22	67
Total	161	176	267	604

Table 4.—Percent operators in each category in returns and as estimated.

Type of operator	Percent in returns	Estimated percent active operators
Offshore charter	52.00	64.73
Inshore/offshore charter	2.86	2.81
Guide boat	34.29	21.36
Head boat	10.86	11.09
Total	100.00	100.00

Table 5.—Estimated percent returns by locality and type of operation.

Type of operation	N.W. coast	W. coast	Fla. Keys	Total area
Offshore charter				
Total returns	22	32	37	91
Estimated population receiving	138	99	154	391
Estimated percent return	15.94	32.32	24.02	23.27
On-/Offshore charter				
Total returns		3	2	5
Estimated population receiving	0	9	8	17
Estimated percent returns		33.33	25.00	29.41
Guide				
Total returns		15	[1]46	61
Estimated population receiving	0	46	83	129
Percent returns		32.61	[2]36.21	[2]34.62
Head				
Total returns	6	7	6	19
Estimated population receiving	23	22	22	67
Percent returns	26.09	31.82	27.27	28.36

[1]Includes return of 25 short versions of the questionnaire.
[2]The 25 persons who sent in short versions of the questionnaire were subtracted from both the population and the returns before calculating percent to correct for the different situations.

Table 6.—Percent effort for fish species in the offshore charter-boat fisheries, by season and coastal area.

Species	Northwest Florida Spr. n=19	Sum. n=20	Fall n=15	Win. n=7	West Florida Spr. n=10	Sum. n=11	Fall n=10	Win. n=10	Florida Keys Spr. n=18	Sum. n=15	Fall n=15	Win. n=19
Bluewater species												
Billfish	2.0	6.0	5.6						15.5	9.5	39.3	41.8
Dolphin	2.6	1.9	1.0						39.2	49.3	1.7	
Sharks									3.1	2.7	4.7	4.0
Tuna									4.2	6.8	6.7	2.4
Wahoo											1.7	0.8
Combined bluewater[1]		8.4							68.9	86.4	62.0	49.5
Reef species												
Grouper	31.3	25.2	24.0	62.9	22.2	54.6	68.5	73.5	1.7	3.3	6.9	3.3
Snapper					8.5	7.3	2.5	3.5	11.4	1.5	2.4	1.5
Grunts								2.5				
Seabass				2.9		2.3	1.0	2.5				
Tilefish										0.9	4.0	
Combined reef[1]	38.7	34.0	36.0	78.6	31.2	66.4	72.0	77.0	13.1	6.7	16.3	5.9
Coastal pelagic												
King mackerel	31.4	49.5	50.7	7.9	49.0		19.0	13.0	3.9		9.3	34.3
Spanish mackerel	5.0				4.0	10.0	2.0	2.0				2.1
Amberjack	7.6	6.3	6.7		7.0	8.6	5.0		3.3		5.5	
Other												
Barracuda									2.5	2.7	5.6	2.1
Cobia	10.5											
Tarpon					4.0				2.2			
Misc. (redfish, flounder, etc.)	2.2	0.8		13.6	4.8	15.0	2.0	3.0	6.1	4.2	1.3	4.0

[1]Combined values are not necessarily totals for column categories but are given as reported.

of each area and type of operation (Tables 6-9).

Offshore Charter

Percent dependence of the charter-boat industry on fish species and species groups during each season varied among the regions and, therefore, is presented separately for each region (Table 6).

Northwest Florida Spring, summer, and fall were the principal fishing seasons in northwest Florida. The species of greatest importance to offshore charter-boat operations during all of these seasons was king mackerel, *Scomberomorus cavalla*. Reef fishes, particularly grouper (Serranidae), were second in importance. Cobia, *Rachycentron canadum*, was next in importance during the spring. Amberjack, *Seriola dumerili*, and bluewater fish, particularly billfish

Table 7.—Recent effort for fish species in the inshore-offshore charter-boat fisheries, by season and coastal area.

Fishery and species	West Florida Spr. n=11	Sum. n=9	Fall n=7	Win. n=7	Florida Keys Spr. n=6	Sum. n=6	Fall n=6	Win. n=6
Offshore								
Bluewater species								
Dolphin					8.3	29.2	8.3	0.8
Billfish					2.5	2.5	18.3	30.8
Combined bluewater[1]	4.4				10.8	31.7	26.6	31.6
Reef species								
Snapper	9.1	8.9	10.0	12.9	13.3	15.0	13.3	13.3
Grouper	25.9	32.2	27.1	39.3	3.3	3.3	9.2	12.5
Combined reef[1]	35.0	41.1	37.1	52.2	16.6	20.8	22.5	25.8
Coastal pelagics								
King mackerel	5.5		5.0				1.7	7.5
Spanish mackerel	3.6		1.4		5.0		3.3	5.0
Combined mackerel[1]	9.1		6.4	5.7				
Amberjack					3.3	3.3	3.3	1.7
Cobia					4.2	1.0		5.0
Coastal pelagics cont.								
Barracuda								
Shark	3.6	6.7	7.1	5.7				
Total offshore	47.7	52.2	50.6	63.6	55.7	69.3	74.9	84.1
Inshore								
Tarpon	32.6	21.4	5.7		31.7	12.5		4.2
Snook	4.3	10.6	16.4					
Redfish	2.3	2.2	10.0	7.9				
Seatrout	5.0	5.8	2.9					
Sheepshead				21.4				
Permit							8.3	9.2	11.7	5.8
Bonefish							3.3	4.2	12.5	
Other	8.1	7.8	14.4	7.1	1.0	4.7	0.9	5.9
Total Inshore	52.3	47.8	49.4	36.4	44.3	30.6	25.1	15.9

[1]Combined values are not necessarily totals for column categories but are given as reported.

Table 8.—Percent effort for fish species in the guide-boat fisheries, by season and coastal area.

Species	West Florida Spr. n=12	Sum. n=11	Fall n=11	Win. n=9	Florida Keys Spr. n=17	Sum. n=16	Fall n=14	Win. n=13
Tarpon	10.4	18.2	7.3		46.9	43.0	16.1	
Snook	35.0	47.3	29.1					
Redfish	27.7	8.2	36.8	22.8				
Seatrout	17.8	14.6	17.3	48.3				
Permit					8.2	11.1	6.4	6.7
Bonefish					29.2	31.0	50.4	46.6
Snapper		6.4		10.0	5.9	7.5	9.3	9.2
Sheepshead				7.8				
Spanish mackerel	9.1	5.3	9.5	10.1	9.8	7.4	17.8	24.8

Table 9.—Percent effort for fish species in the head-boat fisheries, by season and coastal area.

Species	Northwest Florida Spr. n=5	Sum. n=5	Fall n=5	Win. n=5	West Florida Spr. n=4	Sum. n=4	Fall n=4	Win. n=4	Florida Keys Spr. n=1	Sum. n=1	Fall n=1	Win. n=1
Bluewater species												
Dolphin										5.0		
Reef species												
Snapper	20.0	20.0	20.0	20.0	20.0	20.0	22.5	22.5	50.0		70.0	25.0
Grouper	45.0	40.0	40.0	45.0	2.5	20.0	22.5	22.5	40.0		25.0	20.0
Comb. snapper/grouper[1]					65.0	65.0	70.0	70.0	90.0	95.0	95.0	88.8
Grunts					12.5	12.5	12.5	12.5				
Seabass					12.5	12.5	12.5	12.5				
Triggerfish and others	20.0	20.0	20.0	20.0								
Combined reef[1]	85.0	80.0	80.0	85.0	90.0	90.0	95.0	95.0	90.0	95.0	95.0	88.8
Coastal pelagic												
King mackerel					10.0	10.0	5.0	5.0	10.0			11.3
Amberjack	15.0	20.0	20.0	15.0								
Other												
Sharks											5.0	

[1]Combined values are not necessarily totals for column categories but are given as reported.

(Istiophoridae and Xiphiuridae) were important during the summer and fall. Winter fishing was heavily dependent on grouper. Redfish, *Sciaenops ocellata*; flounder, *Paralichthys* spp; and other species were relatively important during the winter. Some king mackerel also were taken in winter.

West Florida The most important species to the offshore charter-boat industry on the Florida west coast were reef fishes, principally grouper. From 66 to 77 percent of total effort was expended on reef fish during the summer, fall, and winter. Almost 50 percent of effort during the spring was directed at king mackerel. Reef fishes also were important during the spring. Some fishing effort was expended on amberjack during the spring, summer, and fall and on tarpon, *Megalops atlantica*, during the spring. (Dependence on tarpon may be artificially low due to the low response rate from Boca Raton captains, who fish extensively for tarpon.)

Florida Keys The offshore charter-boat fishery in the Florida Keys expended the greatest percent of its effort on bluewater species such as dolphin, *Coryphaena hippurus*, and billfish. Bluewater species accounted for 49.5-86.4 percent of fishing effort, depending on the season. Emphasis was on dolphin during the fall (39.2 percent) and summer (49.3 percent) and on billfish during the fall (39.3 percent) and winter (41.8 percent). King mackerel were important to the fishery during the winter (34.3 percent). Reef fish, particularly snapper and grouper, had some importance, particularly during the spring and fall. Although major dependence was on a few species, the offshore charter-boat fishery had more target species in the Keys than in any other part of the study area. Other targets were sharks (Squaliformes); barracuda, *Sphyraena* spp.; bluefin tuna, *Thunnus thynnus*; amberjack; tilefish, *Lopholatilus* spp. and wahoo, *Acanthocybium solanderi.*

Inshore-Offshore Charter Boats

Target species of the inshore-offshore fishery overlapped those of the other three fisheries and included bluewater, reef, and shallow-flats species (Table 7).

Offshore charter boats at Whale Harbor, Islamorada, Fla.

West Florida Reef fishes and tarpon were the species of major importance to the inshore-offshore charter operations of west Florida. The greatest tarpon fishing activity occurred at Boca Grande and Tampa. Inshore and offshore activities were approximately evenly divided. Tarpon fishing was concentrated in the spring and summer and accounted for almost one-third of fishing effort during those seasons. Percent effort on reef fish ranged from 35 percent in the spring to 52.2 percent in the winter. Other offshore species were king mackerel; Spanish mackerel, *Scomberomorus maculatus*; and sharks. Other inshore species were snook, *Centropomus undecimalis*; redfish; seatrout, *Cynoscion* spp.; and sheepshead, *Calamus penna.*

Florida Keys The inshore-offshore fishery in the Keys was different from that in west Florida in that a larger proportion of effort was expended on offshore species. Percent effort expended on offshore species ranged from 55.7 percent in spring to 84.1 percent in winter. Inshore species receiving attention from this fishery were permit, *Trachinotus falcatus*; tarpon; and bonefish, *Albula vulpes*. The most important of these was tarpon.

Bluewater species and reef fish received an approximately equal amount of interest and together accounted for about 50 percent of fishing effort by the inshore-offshore fishery in the Florida Keys during all four seasons. Fishing effort for billfish ranged from 10.8 percent in spring to 31.7 percent in summer. Emphasis was on dolphin during the spring and summer and on billfish during the fall and winter. Snapper were more important than grouper during the spring and summer, and effort was approximately evenly divided between the two groups during the fall and winter.

Barracuda and cobia were two wide-ranging fish species of some importance to the inshore-offshore fishery in the Keys. Amberjack, king mackerel, and Spanish mackerel were other species sought by this fishery.

Guide Boats

Species dependence of guide boats is presented in Table 8.

Typical vessel in the inshore-offshore charter fleet.

West Florida The primary target species of guide-boat operators on the west coast of Florida were snook; tarpon; redfish; spotted seatrout, *Cynoscion nebulosus*; and gray snapper, *Lutjanus griseus* (Table 8). Snook was the most important species. In spring, summer, and fall, 35 percent, 47.3 percent, and 29.1 percent of fishing effort was directed at snook. Redfish was the second most important species, being first in the fall and second in winter. Seatrout was a close third, being first in importance in winter and third in summer and fall. The many species in the category "other" include Spanish mackerel; grouper; flounder; pompano, *Trachinotus carolinus*; cobia; and bluefish, *Pomatomus saltatrix*. None of these composed more than 2 percent of mean fishing effort in any season.

Florida Keys Bonefish and tarpon were the two species of major importance in the Florida Keys. Permit and gray snapper also were important. Bonefish was most important in fall and winter, with 50.4 percent and 46.6 percent of mean season fishing effort. Tarpon led during spring (46.9 percent) and summer (43.0 percent). Other species listed were cobia, grouper, shark, seatrout, barracuda, snook, and redfish, none of which exceeded 5 percent of mean season fishing effort.

Offshore Head Boats

Reliance on reef fish by the offshore head-boat industry was consistent in all three areas, where this group was targeted by 80 to 95 percent of effort. (Table 9).

Northwest Florida In northwest Florida, grouper was the leading fish group sought; snappers were next in importance, followed by a mix of triggerfish (Balistidae) and other reef species. Amberjack was also important to the industry in this area. Mean percent effort directed at each species or species group was approximately the same each season.

West Florida Snapper and grouper accounted for 65-70 percent of effort by this fishery. Grunts (Pomadasyidae) and seabasses were secondarily important reef fish. Approximately 5-10 percent of effort was expended on mackerel (not specified, but probably king mackerel). Greatest fishing effort was during the spring and summer.

Florida Keys From 88.8 to 95 percent of total effort of the head-boat industry in the Florida Keys was directed toward grouper and snapper. Effort towards snapper predominated, particularly in the fall. King mackerel, dolphin, and sharks were other target species of the offshore head-boat industry in the Florida Keys.

Perceived Problems in the Fishery

Captains were asked to list what they considered to be the major problems facing their industry. Questionnaire returns on this item were analyzed by area and type of operation. Responses from offshore charter, inshore-offshore charter, and head-boat captains are combined. Responses from guide-boat captains are reported separately. Percentages refer to the proportion of reporting captains mentioning the problem. Only those problems mentioned by at least 10 percent of respondents are reported.

Charter- and Head-Boat Problems

The most common problem reported by charter- and head-boat operators in all areas was "declining abundances" of fish, reported by 73 percent of responding captains in northwest Florida, 72 percent in west Florida, and 44 percent in the Florida Keys.

Declining catches (catch-per-unit-effort) of king mackerel in particular were cited as a problem by 50 percent of the captains in northwest Florida, 44 percent in west Florida, and 9 percent in the Florida Keys. The attention given to king mackerel in responses reflected the very low catches of king mackerel in the Gulf of Mexico during the summer and fall migrations of 1976, 1977, and 1978 and also pointed out the great extent to which the charter industry along the Gulf coast has been dependent on king mackerel.

Power-roller-gillnet vessels, which make large catches of king mackerel in south Florida during the winter, were cited as the probable cause of declining

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Head boat returning to Whale Harbor.

recreational catches and a serious threat to the king mackerel stock by 15 percent of responding captains in northwest Florida, 20 percent in west Florida, and 12 percent in the Keys. Declining catches of grouper were mentioned as a problem by 16 percent of respondents from west Florida. Red tide outbreaks, which can greatly reduce the abundance of fish on the nearshore reefs, were indicated as a problem of major concern by 24 percent of responding captains on the west coast.

A decrease in baitfish, balao, *Hemiramphis balao*, was cited as a problem by 15 percent of responding captains from the Florida Keys. The decline was attributed to commercial fishing operations directed at balao.

The second most commonly reported problem in all three areas was increasingly high operating costs (mentioned by 68 percent of captains in northwest Florida, 36 percent in west Florida, and 38 percent in the Keys). Fuel-cost increases in particular were cited by 36, 16, and 21 percent of captains in northwest Florida, west Florida, and the Keys, respectively.

Other problems varied with area and often reflected local issues. In northwest Florida, "excessive government controls and regulations" were cited by 14 percent of responding captains. This problem appeared to be related to relatively high percentage of charter vessels in that area which are licensed to carry more than six passengers. Stringent licensing requirements, extra equipment, and Coast Guard inspections required for these vessels were considered to be an annoying addition to a captain's work load and expenses. Weather was considered a problem by 20 percent of west-coast captains. Severe weather during the previous two winter tourist seasons had caused significant loss of income. Pollution and environmental damage were cited as a problem by 16 percent of west-coast captains.

In the Keys, three often reported problems were "increasing use of fish traps," "competition from corporation boats," and "excessive catches by some sport fishermen." Charter-boat captains and others perceive that the use of fish traps by commercial fishermen is thought to have been increasing in the Keys and fear that overfishing of the reefs will result. Corporation boats are boats owned by a corporation not primarily concerned with charter fishing. These vessels are used partially for entertainment of business clients and by the corporate officers and owners. They employ a professional captain, who operates the vessel as a charter boat when it is not being used for company activities. Captial investment often is much greater than in owner-operated vessels, and corporation boats often are larger and more attractive to the customer, while the charter fee they charge usually is the same as that of owner-operated boats. Owner-captains viewed the corporation boats as unfair competition. The highest percentage of corporation boats were found at Islamorada. Many other problems were listed, but none by more than 10 percent of those responding.

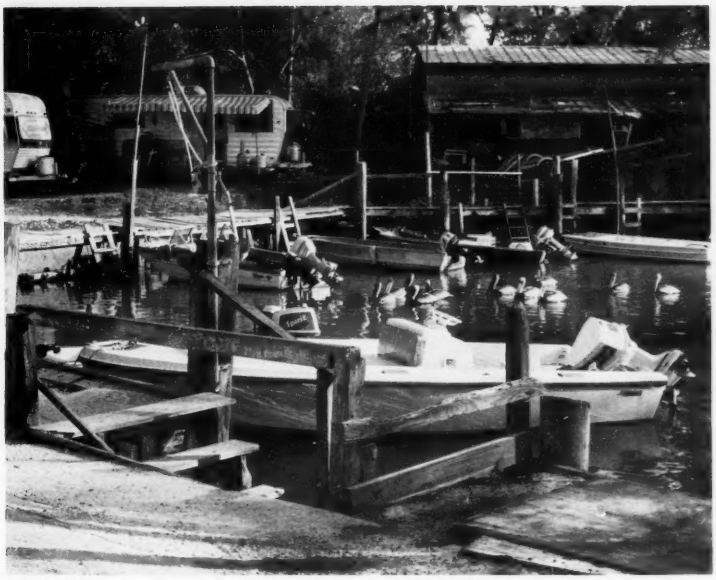
Guide Boat Problems

A lack of fish and high operating costs were the major concerns of guide-boat captains. Thirty-three percent of respondents on the west coast noted shortages of fish in general as a problem, whereas 17 percent mentioned snook specifically. They attributed fish declines to commercial gillnet operators fishing in small boats for mullet, *Mugil cephalus*; seatrout; redfish; and pompano. In particular, they considered this group responsible for declines in catches of seatrout and redfish in Everglades National Park. Thirty-three percent of responding captains viewed pollution and other environmental damages as factors contributing to fish declines.

In the Keys, 63 percent of responding captains cited declining catches (catch-per-unit-effort) as a major problem. They attributed this problem to gillnet fishermen (35 percent), lack of sufficient water flow from the Everglades (38 percent), and pollution (25 percent). High operating costs were a major concern of 33 percent of responding west-coast captains and 19 percent of respondents from the Keys.

Discussion

Changes in paying-passenger recreational fisheries that have occurred since



A typical boat used by guides lies in port at Chokoloska, Fla.

Table 10.—Percent species preference in early 1960's[1] and percent effort for target species in 1977 of the offshore charter-boat fishery in the three regions.

	1960		1977	
Area	Species	%	Species	%
N.W. Florida			Grouper/ snapper	[2]47
	Red snapper	43	King mackerel	35
	King mackerel	38	Amberjack	5
	Black grouper	14	Billfish	3
	Common dolphin	4	Cobia	3
	Spanish mackerel	1		
W. Florida[3]	King mackerel	51	Grouper	53
	Tarpon	18	King mackerel	19
	Spanish mackerel	15	Snapper	6
	Black grouper	11	Amberjack	5
	Red grouper	2	Spanish mackerel	4
	Sailfish	2	Tarpon	1
Florida Keys[4]	Sailfish	43	Billfish	27
	King mackerel	29	Common dolphin	23
	Common dolphin	14	King mackerel	11
	Barracuda	14	Tuna	5
			Sharks	4
			Grouper	4
			Snapper	4
			Barracuda	3
			Amberjack	2

[1]Adapted from Moe (1963).
[2]Possibly 35 percent was grouper. There was a problem in clarity with the way snapper and grouper were reported, as some respondents had separate categories for the two taxa and others put them together.
[3]Effort data of inshore-offshore vessels were added to that of offshore vessels in west Florida for 1977 to be more comparable with Moe's (1963) coverage.
[4]Moe (1963) reported only the top four species for Monroe County. Note: Numbers for the two times are not entirely comparable due to differences in the way they were originally compiled.

the study by Moe (1963) can possibly be attributed to the declines in catch-per-unit-effort noted by the captains. Changes are of two types: 1) A shift in relative importance of target species and 2) a shift in the relative levels of activity of the three regions.

Moe (1963) determined the three most preferred species in each coastal county in Florida in the early 1960's. For comparison with our data, Moe's data were recompiled to give a picture of the principal target species in the three regions of the study area. We assigned the values 3, 2, and 1, respectively, to the species Moe (1963) had ranked number 1, 2, and 3 in each county, then multiplied these numbers by the number of vessels operating in each county. The rank for each species obtained by this method was divided by the sum of the ranks for all species to get a rough approximation of the regional relative importance of the principal species named by Moe (1963). The results are shown with estimates of percent effort on target species in the present study in Table 10. Due to the differences in the original compiling methods, small differences in relative importance should be disregarded, but large differences probably are meaningful.

A decline in relative importance of the snappers as target species in northwest Florida waters is suggested by comparison of the two sets of data. According to the Gulf of Mexico Fishery Management Plan[1], a decline in reef fish stocks, probably due to overfishing, has occurred in some areas of the Gulf of Mexico.

King mackerel has decreased sharply in relative importance as a target species in west Florida but not in northwest Florida. The decrease in relative importance of this species in west Florida reflects the very low catches of king mackerel experienced in the eastern Gulf of Mexico since 1975. It is not yet clear whether the lack of availability is due to an actual decline in stock abundances or to unusually cold winters, which may have caused king mackerel stocks to shift their migration routes farther offshore to avoid cold water[2].

Spanish mackerel also has decreased in relative importance to west Florida charter-boat fisheries. Amberjack, billfish, and cobia replaced dolphin and Spanish mackerel as principal target species in northwest Florida charter-boat fisheries. Amberjack also has become more important to west Florida fisheries.

The relatively low dependence on tarpon in west Florida in 1977 may be an artifact caused by a low rate of response to the questionnaire from tarpon-boat captains in Boca Grande.

[1]Draft Fishery Management Plan for Reef Fishes. Gulf of Mexico Fishery Management Council, Suite 881, 5401 Kennedy Blvd., Tampa, FL 33609.

[2]Draft Fishery Management Plan for Migratory Coastal Pelagics. Gulf of Mexico Fishery Management Council, Suite 881, 5401 Kennedy Blvd., Tampa, FL 33609.

Back-country fishing among mangrove islands near Goodland, Fla.

Recreational effort of offshore-charter boats in the Florida Keys appears to have diversified, with a larger number of important target species today than when Moe (1963) made his survey. The decline in relative importance of sailfish to the fishery is consistent with the general trend toward diversification. Dolphin has increased in relative importance to the fishery since the time of Moe's (1963) study.

Moe (1963) determined the number of charter and head boats operating in each of the coastal counties. His county results, which we have compiled for northwest Florida, west Florida, and the Florida Keys, are given with our estimates for 1977 in Table 11.

Table 11.—Number of offshore-charter and head boats operating in the three regions in the early 1960's and 1977.

Region	Charter boats		Head boats	
	1960[1]	1977[2]	1960	1977
Northwest Florida	126	138	48	23
West Florida	157	108	28	22
Florida Keys	97	151	9	23
Total	380	397	85	68

[1]Based on Moe (1963).
[2]Inshore-offshore vessels are included with offshore vessels in 1977 numbers.

The total number of charter boats operating in the study area has increased slightly since the period of Moe's study (1963). The number of head boats operating in the study area has declined considerably in the past 17 years. While the charter boat industry has increased by more than 50 percent in the Florida Keys and expanded slightly in northwest Florida over the past 17 years, activity in west Florida has declined by approximately one-third. Head-boat activity has increased in the Florida Keys but decreased in the other two areas.

Several factors combine to give the Florida Keys a current advantage over west and northwest Florida, with respect to paying-passenger fisheries. The weather is more consistently favorable in this area, and support facilities are increasing to the point where their lack is no longer a serious handicap. Furthermore, dependence on fish stocks is more diversified in the Keys than in the other areas, and declining catch-per-unit-effort of major target species was a problem of the industry cited by fewer captains in the Florida Keys than elsewhere. The decline in number of operators in both west and northwest Florida that has accompanied the loss of dependable target species such as red snapper and king mackerel in these areas, suggest that paying recreational fishermen tend to abandon ports where they perceive a low probability of catching fish, dealing an economic blow to the local paying-passenger fisheries.

The captains have not been silent about their perceived problems and have made some of them major political issues in the state. For instance, legislation placing limited gear restrictions on king mackerel gillnets and outlawing fish traps in state waters has been enacted. A recent decision by the National Park Service, if not overturned, will exclude commercial fishing from Everglades National Park.

Summary

An estimated 604 active paying-passenger captains operated on the Florida Gulf coast and in the Florida Keys in 1977, approximately 44.2 percent were located in the Keys, 29.1 percent were located in west Florida, and 26.7 percent were located in northwest Florida. An estimated 64.7 percent of the operations were offshore charter boats, 21.4 percent were guide boats, 11.1 percent were head boats, and 2.8 percent were inshore-offshore charter boats.

The total number of offshore and inshore-offshore operations changed little since a previous study (Moe, 1963), but the number of operations increased by more than 50 percent in the Keys, increased slightly in northwest Florida, and decreased by approximately 33 percent in west Florida in the 17-year period between studies. The total number of head-boat vessels declined, although the number of vessels in the Keys almost tripled, the number of vessels in northwest Florida decreased by one-half, and a slight decrease occurred in west Florida.

The number of target species has increased in the offshore fisheries of the Florida Keys. Species dependence has changed in west Florida and northwest Florida, probably reflecting a decline in catch-per-unit-effort of king mackerel and red snapper.

Acknowledgments

The authors greatly appreciate the reviews provided by James Zweifel, James Zuboy, and Larry Massey at the Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Miami, Fla., and Michael Justen at the Southeast Regional Office, National Marine Fisheries Service, NOAA, St. Petersburg, Fla.

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Possible Temperature Effects on Charter Boat Catches of King Mackerel and Other Coastal Pelagic Species in Northwest Florida

WILLIAM A. FABLE, Jr., HAROLD A. BRUSHER, LEE TRENT, and JOE FINNEGAN, Jr.

ABSTRACT—Dramatic changes occurred in the landings, species composition, and sizes of fishes caught in the charter boat fishery for pelagic fishes in northwest Florida in the summers of 1977 and 1978. These changes occurred after two of the coldest winters in 100 years. Catch per hour (CPH) of king mackerel, the target species, declined greatly, while CPH of Atlantic bonito and bluefish increased. Data indicated that warm winters resulted in high CPH, while cool winters resulted in low CPH. We concluded that catch rates of king mackerel were related to temperatures of the preceding winter.

Introduction

A large fleet of charter sportfishing boats and numerous private boats seek pelagic fishes during the warmer months in northwest Florida. Trolling techniques are usually employed and numerous pelagic species are caught: King mackerel, *Scomberomorus cavalla*; Spanish mackerel, *S. maculatus*; bluefish, *Pomatomus saltatrix*; blue runner, *Caranx crysos*; little tunny, *Euthynnus alletteratus*; Atlantic bonito, *Sarda sarda*; and dolphin, *Coryphaena hippurus*.

The areas of greatest trolling effort in northwest Florida are adjacent to Panama City (Bay County) and Destin (Okaloosa County). Historically, this fishery has been mostly dependent on catches of king mackerel (Irby, 1974; Brusher et al., 1978; Fisher, 1978). Sutherland and Fable (1980) have shown that these king mackerel winter off southeast Florida.

Studies by the National Marine Fisheries Service (NMFS) indicated that dramatic changes in the landings, species composition, and sizes of fishes have occurred during the summers of 1977 and 1978 in the charter boat pelagic fishery off Panama City. These changes occurred after equally dramatic changes in air temperatures during the preceding winters.

Our paper describes and discusses the changes in the northwest Florida charter boat pelagic fishery and discusses temperature as a possible cause for the observed changes.

Source and Treatment of Data

Catch records from the Panama City area were obtained from the logs or log summaries of the *Fu-Lin-Yu II*, a charter boat that fishes only by trolling and which is owned and operated by the second author. The available records consisted of total numbers of trolled hours and the numbers of fish of each species that were caught each month during 1970, 1973-76, and 1978-79 and each year for 1971 and 1977. No records were available for 1972. Eight charter boat captains that fish in the Panama City area were consulted to determine if these logs were representative. Each stated, based on memory, that the catch records were generally typical of charter boat catches in this area during the specified periods. All data were tabulated by year or month, and species composition and catch per unit effort were determined. Catch per unit effort for this report is defined as the catch per hour (CPH) for each species. Annual catch composition and CPH for each species that comprised over 3 percent of the catch for the entire 8 years were plotted.

We supplemented our catch information with data provided by J. A. Browder and C. J. Davis (NMFS and Gulf Fishery Management Council, November, 1979, pers. commun.) on charterboat catch rates of king mackerel from Destin, Fla., and Orange Beach Ala. Data from charter boat captain A. L. Hilpert in Destin were available from 1973 through 1977 and included catch-per-hour figures. Orange Beach landings by charter boat captain T. Clark included data from 1965 through 1977 and were in catch-per-day figures, which we converted to catch-per-hour by dividing by four (assuming an average of four hours of fishing each day).

Data for evaluating sizes of king mackerel and bluefish were obtained by the NMFS Panama City Laboratory in conjunction with life history studies. Data on bluefish from the Panama City area were acquired from gillnet catches in 1973 (Trent and Pristas, 1977) and gillnet, haul seine, and hook and line catches in 1977-78. King mackerel data were acquired from fish caught on hook and line off North Carolina, northwest Florida, and Texas in 1977 and 1978[1]. Fork length (FL), to the nearest millimeter was measured and grouped into 5.0 cm (king mackerel) or 2.5 cm (bluefish) intervals. Length data on king mackerel from Panama City in 1977 and 1978 were divided into small fish (<700 mm FL) and large fish (≥700 mm FL) and were plotted by month.

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[1]Trent, L., R. O. Williams, R. G. Taylor, C. H. Saloman, and C. S. Manooch III. In prep. Seasonal changes in the size and sex ratio of king mackerel *(Scomberomorus cavalla)* and comparisons among geographic locations in the southeastern United States.

Long-term water-temperature data were unavailable for the northeast Gulf of Mexico. Tolbert and Austin (1959) stated that water temperatures closely parallel air temperatures at Panama City. Pensacola, Fla., is approximately 100 miles west of Panama City and air temperatures are similar. We acquired the annual summary of local climatological data with comparative data for Pensacola from the Environmental Data and Information Service (EDIS, 1978). Data for January and February 1979 were taken from monthly climatological data pamphlets, also provided by EDIS. Average winter (December-February) air temperatures were computed and plotted.

Species Composition and CPH

Seven species composed 98.9 percent of the total of 22,349 fish caught by the *Fu-Lin-Yu II* during 1970-71 and 1973-79 (Table 1). King mackerel predominated and composed 60.8 percent of the total catch. Other species composing over 3 percent of the total catch were: Atlantic bonito (14.6), bluefish (5.4), blue runner (5.3), little tunny (5.3), Spanish mackerel (3.8), and dolphin (3.7).

The composition of the catch changed dramatically during the latter half of the 9-year (1970-79) period (Fig. 1) King mackerel composed over 80 percent of the total catch each year through 1975 and then declined as follows: 1976 (65.3

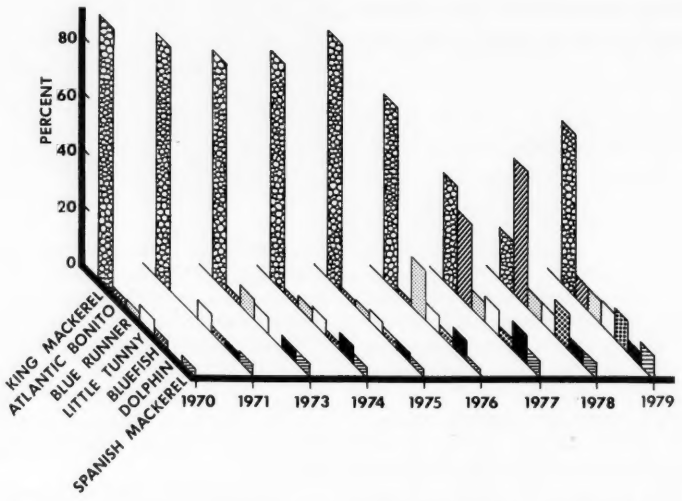

Figure 1.—Percent composition of the seven most abundant species caught during 1970-71 and 1973-79 in Panama City, Fla.

Table 1.—Catches of coastal pelagic fishes from the *Fu-Lin-Yu II* by trolling in the Panama City, Florida, area.

	Year (and hours fished)																	
	1970 (552)		1971 (550)		1973 (495)		1974 (329)		1975 (592)		1976 (589)		1977 (676)		1978 (706)		1979 (781)	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Total
King mackerel *Scomberomorus cavalla*	2,263	92.9	1,963	86.9	1,400	81.5	650	81.5	2,270	88.4	1,426	65.3	976	38.7	909	18.9	1,742	57.2	13,599
Atlantic bonito *Sarda sarda*	18	0.7	0	0.0	1	0.1	2	0.3	8	0.3	9	0.4	742	29.5	2,266	47.0	216	7.1	3,262
Bluefish *Pomatomus saltatrix*	12	0.5	62	2.7	0	0.0	2	0.3	71	2.8	68	3.1	79	3.1	611	12.7	296	9.7	1,201
Blue runner *Caranx crysos*	15	0.6	0	0.0	109	6.3	27	3.4	11	0.4	381	17.5	150	5.9	290	6.0	205	6.7	1,188
Little tunny *Euthynnus alletteratus*	75	3.1	126	5.6	77	4.5	31	3.9	68	2.7	111	5.1	193	7.7	266	5.5	231	7.6	1,178
Spanish mackerel *Scomberomorus maculatus*	45	1.9	70	3.1	53	3.1	23	2.9	69	2.7	7	0.3	130	5.1	212	4.4	231	7.6	840
Dolphin *Coryphaena hippurus*	1	0.0	37	1.6	55	3.2	38	4.8	46	1.8	151	6.9	237	9.4	176	3.7	93	3.1	834
Ladyfish *Elops saurus*	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	19	0.9	0	0.0	79	1.6	8	0.3	106
Blackfin tuna *Thunnus atlanticus*	0	0.0	0	0.0	16	0.9	21	2.6	18	0.7	0	0.0	0	0.0	0	0.0	1	0.0	56
Crevalle jack *Caranx hippos*	5	0.2	0	0.0	7	0.4	1	0.1	6	0.2	3	0.1	3	0.1	6	0.1	20	0.7	51
Cobia *Rachycentron canadum*	1	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	0.2	6	0.2	2	0.0	4	0.1	18
Greater amberjack *Seriola dumerili*	0	0.0	0	0.0	0	0.0	3	0.4	1	0.0	3	0.1	0	0.0	0	0.0	0	0.0	7
Wahoo *Acanthocybium solanderi*	2	0.1	0	0.0	0	0.0	0	0.0	1	0.0	0	0.0	2	0.1	1	0.0	0	0.0	6
Great barracuda *Sphyraena barracuda*	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0	1	0.0	1	0.0	3
Total	2,437		2,258		1,718		798		2,569		2,183		2,519		4,819		3,048		22,349

percent), 1977 (38.7 percent), and 1978 (18.0 percent). In 1979, they made up 57.2 percent of the catch. Atlantic bonito were rare in the catches until 1977 during which they composed 29.5 percent of the catch. In 1978 they comprised 47.0 percent of the catch, but in 1979 they dropped to only 7.1 percent of the catch. This species was unreported from the northern Gulf until 1966 when Boschung (1966) documented its occurrences east of the Mississippi Delta.

The CPH data reflect two periods of declining abundance of king mackerel in the Panama City area: Mean CPH delined from 4.1 in 1970 to 2.0 in 1974 and from 3.8 in 1975 to 1.3 in 1978 (Fig. 2). The CPH of king mackerel from Panama City, Destin, and Orange Beach is shown in Table 2 and plotted in Figure 3. From 1973 through 1977 the CPH values from all areas show the same trends. They decrease from 1973 to 1974, increase in 1975, then decrease in 1976 and again in 1977.

The assumption that these CPH data reflect abundance, or catchability, of king mackerel in the area seems valid. King mackerel is the target species for the local charter boat fleet and when they are available the captains fish for them almost exclusively. The CPH by the *Fu-Lin-Yu II* of 3.8 king mackerel in 1975 agrees closely with the average of 3.9 for the entire Panama City charter boat fleet in 1975 (Brusher et al., 1978).

During 1975-78, the CPH of Atlantic bonito and bluefish notably increased as the CPH of king mackerel declined (Fig. 2). For the 9 years of record, the CPH of Atlantic bonito increased dramatically in 1977-78; the CPH of blue runner was especially high in 1976; the CPH of dolphin was highest in 1977; the CPH of little tunny and bluefish were highest in 1978, and the CPH of Spanish mackerel was highest in 1979. During 1970-74, the CPH of other species did not increase as the CPH of king mackerel declined.

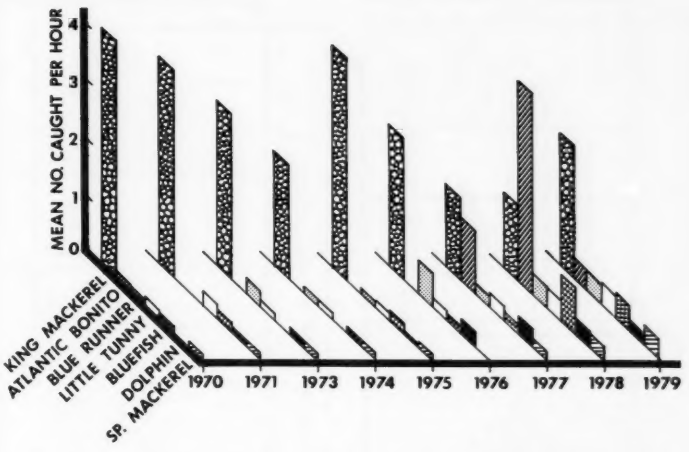

Figure 2.—Mean catch per hour of the seven most abundant species caught during 1970-71 and 1973-79 in Panama City, Fla.

Table 2.—Catch per hour of king mackerel from three areas.

Year	Panama City	Destin	Orange Beach	$\bar{X}$
1965	—	—	0.6	—
1966	—	—	1.9	—
1967	—	—	1.5	—
1968	—	—	1.6	—
1969	—	—	1.6	—
1970	4.1	—	1.1	2.6
1971	3.6	—	0.8	2.2
1972	—	—	1.1	—
1973	2.8	2.5	2.8	2.7
1974	2.0	1.4	2.0	1.8
1975	3.8	3.1	3.5	3.5
1976	2.4	1.7	0.7	1.6
1977	1.4	0.7	0.2	0.8
1978	1.3	—	—	—
1979	2.2	—	—	—

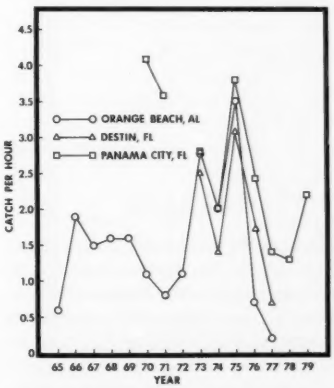

Figure 3.—King mackerel catch per hour from three areas of the northeastern Gulf of Mexico.

Seasonality of the Catch

In general, king mackerel are available to the fishery in the Panama City area in April, are abundant during June to November, and are most abundant, or catchable, in September (Fig. 4). Deviations from this general sequence occurred, however, during the 7 years on record (Fig. 5). During 1970, 1973, and 1974 the pattern of the CPH was bimodal, with relatively high CPH occurring in May or June and again in September or November. Although the CPH by the *Fu-Lin-Yu II* did not indicate a bimodal pattern in 1975, data from the charter boat fleet had peaks of CPH in June and September (Brusher et al., 1978). In 1976, the CPH was extremely low until June and in 1978 until July. Again, bimodal distributions of the CPH were indicated in 1976, 1978, and 1979. Catch rates were good in May of 1979 and very high in August. Highest CPH occurred in August or September in all years except 1974.

The CPH of the remaining six species (Fig. 4) indicated that Atlantic bonito, blue runner, little tunny, and dolphin were most abundant in the catches during June or July, while bluefish were most abundant in May and November and Spanish mackerel in March.

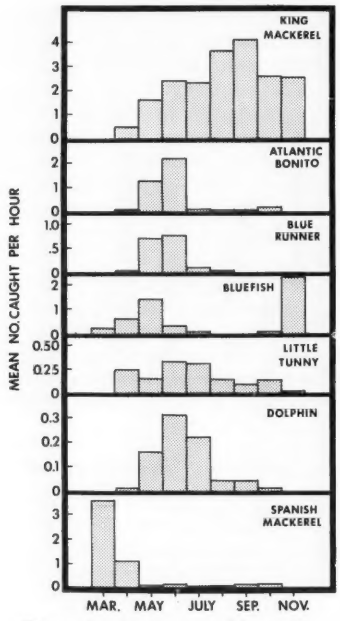

Figure 4.—Average monthly catch per hour of the seven most abundant species caught in Panama City, Fla.

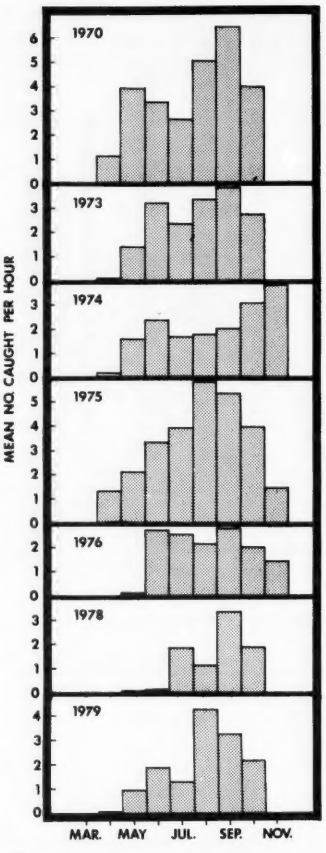

Figure 5.—Average monthly catch per hour of king mackerel by year in Panama City, Fla.

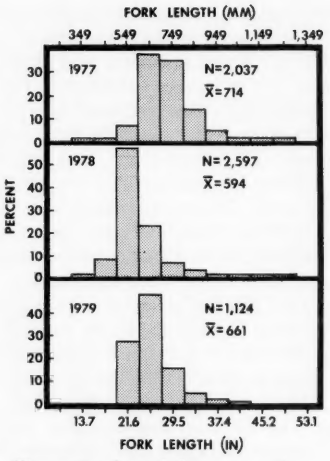

Figure 6.—Length-frequency distributions of king mackerel in Panama City Fla., during 1977-79.

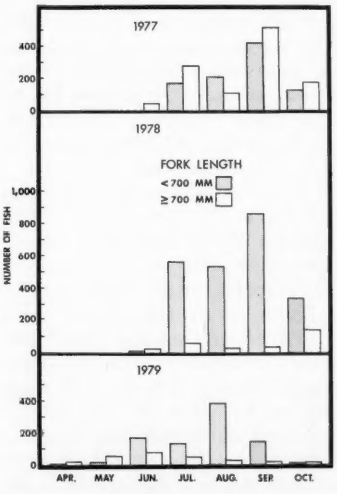

Figure 7.—Monthly distribution of small (<700 mm FL) and large (≥700 mm FL) king mackerel sampled during 1977-79 in Panama City, Fla.

Sizes of Fish

Discussions with charter boat captains indicated that the average size of king mackerel caught in the Panama City area during 1978 was the smallest they could remember. A size comparison (footnote 1) indicated that catches of king mackerel in the Panama City area were composed of many more small fish during 1978 than during 1977 or 1979 (Fig. 6). When fish sizes from other areas were compared, lengths of king mackerel from Panama City averaged about the same as those from North Carolina and Texas in 1977, whereas those from Panama City averaged much smaller in 1978. Mean fork lengths by area and year were: Panama City—714 mm (1977), 594 mm (1978), 661 mm (1979); North Carolina—713 mm (1977), 847 mm (1978); Texas—785 mm (1977), 872 mm (1978). No data from areas other than Panama City were available for 1979.

Sizes of king mackerel caught in the Panama City area varied seasonally (footnote 1). During each year, mean lengths were greatest at the beginning of the fishing season, declined to a seasonal low in August, and then increased in September or October. The data, grouped into small (<700 mm FL) and large fish (≥700 mm FL), indicated that during 1977 large fish were more abundant than small fish during June, July, September, and October, whereas in 1978, small fish predominated in every month except June (Fig. 7). In 1979, large fish were more abundant in April, May, and October.

Large bluefish (along with the usual

Table 3.—Average winter (December-February) air temperatures for Pensacola, Fla. 1964-79.

Winter	Avg. Temp. °F	Avg. Temp. °C	Winter	Avg. Temp. °F	Avg. Temp. °C
1963-64	47.6	8.6	1971-72	58.9	14.9
1964-65	53.7	12.0	1972-73	53.7	12.0
1965-66	51.0	10.5	1973-74	58.5	14.7
1966-67	51.9	11.0	1974-75	58.2	14.5
1967-68	51.2	10.6	1975-76	54.5	12.5
1968-69	51.3	10.7	1976-77	47.5	8.6
1969-70	50.4	10.2	1977-78	48.0	8.9
1970-71	54.6	12.5	1978-79	50.7	10.4

small bluefish) occurred in the Panama City area in the spring of 1978 for the first time that local fishermen could remember. These large fish averaged 758 mm FL (about 12 pounds or 5.5 kg), decidedly larger than we had observed in 1973 and 1977 (Fig. 8). Large bluefish occur in March and April off southeast Florida (DeSylva, 1976) but are rarely taken in the Gulf of Mexico. Most of the large bluefish caught off southeast Florida during early spring range between 10 and 14 pounds (4.5 and 6.5 kg) (Dunaway, 1979).

Temperature

The average winter (December-February) air temperatures for Pensacola are shown in Table 3 and Figure 9. The average winter temperature for an 84-year period (1879-1963) was 54.3°F (12.4°C) (EDIS, 1978). For this same period, the coldest winter on record (1957-58) averaged 48.7°F (9.3°C). The table and figure show that the winters of 1963-64, 1976-77, and 1977-78 all averaged lower than this previous record. It was very unusual that two of these low temperature winters occurred consecutively (1976-77 and 1977-78).

Discussion

The fishing seasons of 1977 and 1978 showed not only changes in the arrival time and size and abundance of king mackerel, but also differences in abundance of Atlantic bonito and size composition of the bluefish catch. This led us to believe that some environmental influence was primarily responsible for the changes in the charter boat catches, since several species showed changes in landings.

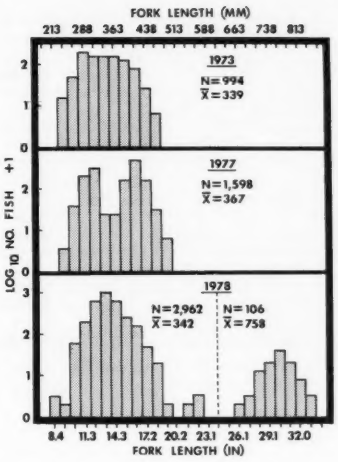

Figure 8.—Length-frequency distributions of bluefish in Panama City, Fla.

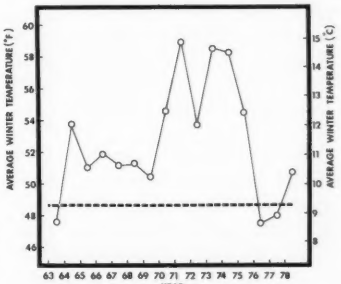

Figure 9.—Average winter air temperatures for Pensacola, Fla. Dashed line indicates coldest winter (1957-58) during the period 1879-1963.

To relate the CPH to winter temperature, we developed a scatter diagram of the CPH from Table 2 and the average preceding winter air temperatures from Table 3 (Fig. 10). The diagram revealed a relationship between winter air temperature and the CPH of the following fishing season. Generally, warm winters resulted in high CPH, while cool winters resulted in low CPH. Although outlying

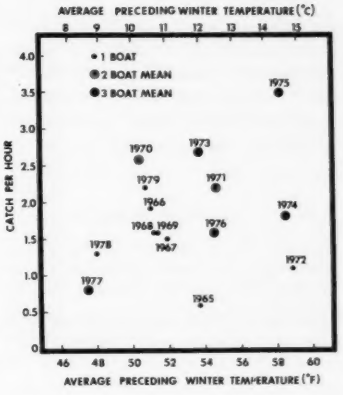

Figure 10.—King mackerel catch per hour plotted against preceding winter average air temperature.

points (1965, 1972) did not agree with this tendency, these points were based on the CPH values from one boat, whereas the points based on the CPH values from three boats (1973-77) did support this relationship. Although too few data were available to be conclusive, the highest CPH (1975) occurred after one of the warmest winters, and two of the lowest CPH's (1977 and 1978) occurred after the two coldest winters.

Williams and Taylor (1980) have stated that the first appearance of king mackerel off west central Florida is directly dependent on offshore water temperature and indirectly on air temperatures of the preceding winter. Our data suggest that catch rates in northwest Florida are also related to temperatures. We will continue to monitor the catch records of charter boats in the future to determine more definitely their relationship to environmental factors.

Acknowledgments

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U. S. Fishery Catch Rises for Third Year

The domestic catch of fish sold for consumption and industrial processing in the United States rose for the third consecutive year in 1980, reaching a record 6.5 billion pounds. The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) said last year's catch was 3 percent higher than the year before, but about the same in value, $2.2 billion.

NOAA also noted that the domestic fishery's share of the commercial U. S. seafood market has risen from 46.5 percent in 1976 to 57.1 percent a year ago. The remainder was supplied by imports. The agency said the catch of edible fish and shellfish last year was up 10 percent over 1979, totaling 3.7 billion pounds. About 2.5 billion pounds of menhaden, a fish used to make oil and fertilizer, also was landed in 1980. It accounted for 38 percent of the total.

Salmon proved the second most important species caught in both quantity and value. Crabs and tuna ranked third and fourth. Shrimp were fifth, but the highest in value.

Leading U. S. ports in quantity of commercial fishery landings were, in descending order, Cameron, La.; San Pedro, Calif.; Pascagoula-Moss Point, Miss.; Empire-Venice, La.; and Dulac-Chauvin, La. Menhaden was the principal species landed at all these ports except San Pedro. There, tuna was the principal catch.

Louisiana led all states in volume with 1.4 billion pounds. It was followed by Alaska with 1.1 billion pounds; California with 804.3 million pounds; Virginia with 634.5 million pounds; and Massachusetts with 438.4 million pounds. The Alaska catch was valued at $560.6 million. It was followed by California with $323.4 million; Massachusetts with $178.6 million; and Louisiana with $178 million.

Gulf Stream Charts Save Time and Fuel

For Gulf Coast fishermen, a key to good fishing and staying out of Cuban waters is knowing the exact location of the Gulf of Mexico's Loop Current and the Gulf Stream. Courtesy of the Federal Government, that information now is as handy to them as the nearest telephone. It also is available on most Florida stations of the NOAA Weather Radio network.

The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) now provides updates every Monday, Wednesday, and Friday on the current and stream through annotated charts available by telecopier and via the broadcasts.

The data, culled from NOAA satellite imagery and other sources, help fishermen pinpoint schools of temperature-sensitive fish found near the Gulf Stream and determine the danger of the current which could carry fishermen into Cuban waters. It covers waters from Florida north to Cape Hatteras and Florida and the Gulf of Mexico. Separate charts are issued for both areas.

Donald C. Gaby, manager of the Miami station of NOAA's National Earth Satellite Service (NESS), said the new service also helps conserve fuel. He said it allows fishermen to determine when the Gulf Stream is too far out in the Atlantic north of Cuba to make fishing economical.

Ships also use it to locate the stream to shave transit time, Gaby noted. C. F. Industries, Inc[1], Long Grove, Ill., reports saving 6 hours and 1,500 gallons of fuel on a round trip from New Orleans to Norfolk, Va. The company's 600-foot bulk carrier costs $1,200 an hour to operate.

Persons interested in recording charts by telecopier should call (305) 661-0738. Queries about them or telecopier reception should be directed to the Miami station at (305) 665-4707 or (305) 350-4310.

NOAA's National Weather Service extracts portions of the charts for broadcasts over NOAA Weather Radio stations in Miami, Jacksonville, Key West, Daytona Beach, and West Palm Beach. Miami and Jacksonville broadcast on an FM frequency of 162.550 MHz, while the other stations are on 162.400 MHz. Plans call for NOAA Weather Radio stations at Gulf Coast locations to broadcast the Gulf Loop Current information in the future.

Tuna Habitat: The Eastern Tropical Pacific

The eastern tropical Pacific Ocean covers approximately 6 million square miles, stretching between lat. 40°N and 40°S from the west coast of the Americas to long. 160°W. It is an area of high biological productivity and is the habitat for many species including tuna and porpoise. The major tuna species found in the area are yellowfin and skipjack. Major currents in the eastern tropical Pacific, especially in the vicinity of the Equator, serve as geographical boundaries for certain porpoise stocks.

The average depth of the thermocline (the area of sharp temperature difference between warm surface waters and colder deep waters) is much less in the eastern tropical Pacific then in the

[1]Mention of trade names or commercial products or firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

western—usually less than 150 feet in the eastern area and more than 450 feet in the western. The shallow thermocline serves as a barrier that keeps the tuna from diving deep to escape a net—a characteristic that is known and used by fishermen to increase their catches.

The U. S. tuna purse seine fleet catches six tuna and tunalike species in the eastern tropical Pacific, chiefly yellowfin and skipjack tuna, and small numbers of bluefin tuna, bigeye tuna, black skipjack tuna, and bonito. Only yellowfin tuna are frequently caught in association with schools of porpoise, but tuna may also be found and caught in association with floating objects such as logs and other debris to which they are attracted, or in association with whales or whale sharks. Yellowfin and skipjack tuna make up about 62 and 38 percent, respectively, of the average U. S. purse seine catch from the area.

Field observations indicate that tuna swimming in association with porpoise tend to be larger than those that swim in pure tuna schools; smaller tuna tend to swim in tuna-only schools, and in waters closer to shore. Source: NOAA Office of Public Affairs.

Measuring Fresh Fish Quality

Freshness and spoilage are terms that emphasize quality changes of fresh fish from the time it is caught until it is no longer acceptable as food. Various methods are used to measure the quality changes of fish and, commonly, the senses of sight, smell, and touch are used. However, individuals vary in their assessment of quality and objective methods that do not rely on the senses are continually being evaluated, reports the Northwest and Alaska Fisheries Center's Utilization Research Division (URD).

A number of chemical methods have been developed for measuring freshness or quality changes. They all depend on measuring the concentrations of various breakdown products such as hypoxanthine, malonaldehyde, trimethylamine, and pH which change as quality changes.

In research on the effect of holding systems for fresh fish, it is important to measure objectively the quality changes of the fish. For one of the recent studies, a Torrymeter was used to follow the quality changes in walleye (Alaska) pollock held in ice for 8 days. This instrument was developed at the Torry Research Station in Aberdeen, Scotland, to measure quality changes in fresh fish and is simple to use. Table 1 illustrates how the Torrymeter readings and chemical changes in pollock during iced storage can be used as indices of freshness.

Taste panelists began to detect changes in the pollock after the fifth day of iced storage. The methods chosen to monitor the chemical changes in pollock also indicated that rapid changes began to occur after the fifth day. The Torrymeter measures the progressive change in the dielectric properties of fish tissue during storage and the decreasing readings reflect the decrease in freshness. Although the theory is complicated, the Torrymeter is simple to use (just place the sensing head firmly against the side of the fish) and fast compared with the chemical methods that require laboratory facilities and time for the tests.

The Torrymeter is a new instrument and more tests will be made comparing it with chemical methods. Simple accurate methods to measure quality are always being sought and, because of the complexity of the quality changes, those first changes in the freshness of the fish are the most important for consumer satisfaction.

Jerry Babbitt

Table 1.—Changes in quality parameters of Alaska Pollock held in ice.

Days after catch	Torrymeter readings	Hypoxanthine moles/g	Malonaldehyde moles/100 g	Trimethylamine mg/100 g	pH
1	13.8	0.45	0.12	0.26	6.88
3	8.0	1.02		0.61	6.88
5	4.3	1.28	0.29	0.67	7.10
8	1.08	2.06	0.64	2.20	7.15

Carotenoids for Salmonid Diets

A cooperative research study with Sam Meyers of Louisiana State University, Baton Rouge, La., has been reported by the Northwest and Alaska Fisheries Center's Utilization Research Division (URD). The study will investigate the efficacy of carotenoids derived from crawfish wastes.

Several years ago, the URD developed a process for extracting the naturally occurring carotenoid pigments from shellfish and euphausids using soy oil. This effective procedure is being scaled up by Meyers in a menhaden meal and oil plant in Louisiana. At present, about 20 million pounds of crawfish are harvested in Louisiana, but about 85 percent of this figure becomes waste. This waste can be a useable by-product since it is high in carotenoid pigments.

Currently these natural pigments, and their synthetic analogs, are added to aquaculture diets to impart a desirable pink color to the flesh of salmonids. Based on preliminary figures, the 20 million pound harvest will yield about 18 million pounds of waste by-product containing about 2,700 pounds of carotenoids. At a current price of $400 per pound for the synthetic pigment, this could represent over a $1 million resource.

The URD studies in Seattle, Wash., will test the effectiveness of the extract in typical dry diets in both rainbow trout (here in the laboratory) and those being raised in a local commercial mariculture operation in Puget Sound. Several factors need to be determined about this new product: Its stability during feed manufacture and storage, possible interactions of the extract with other dietary components, and uptake rate by the fish of the pigment. This information will aid in determining the viability of using crawfish as a source of these pigments in aquaculture feeds.

John C. Wekell

New Latin American Joint Fishing Ventures Told

Taiwan and Libya have both recently formed joint venture fishing companies in Latin America. Taiwan already has extensive fishery relations with various Latin American countries, mostly concerning shrimp, tuna, and aquaculture, but this is the first known Libyan fishery venture in the region.

Taiwan-Venezuelan Joint Tuna Venture

A proposal by the Lisneros or Financial Group of Venezuela for a cooperative joint venture with Taiwan for longlining within Venezuela's claimed 200-mile Exclusive Economic Zone (EEZ) has been accepted in principle by the Taiwan Tuna Exporters Association.

Details of the proposal made by Lisneros are: 1) Taiwan is expected to assign six vessels to the project and to pay US$125 for each ton of fish caught by these vessels; 2) the Taiwanese vessels will be allowed to use any port in Venezuela and to buy fuel at domestic Venezuelan prices, 3) catches should be available for sale on the international market as well as on the domestic market in Venezuela, and 4) the joint contract should run for a minimum of 3 years and a maximum of 5 years with the right to negotiate an extension prior to its expiration.

Taiwan has operated longliners in the South Atlantic out of Montevideo, Uruguay, for several years[1]. Uruguay's fuel prices are among the highest in the world because almost all of the petroleum must be imported. As a result, Taiwanese companies have reduced their fishing effort out of Montevideo and for some time have been attempting to find an alternative port for their longliners. Talks were held in both Trinidad and Venezuela, two countries which maintain low domestic fuel prices. Venezuela was especially interested in reaching agreement with Taiwan because local canneries have been increasing the quantity of canned tuna and Venezuelan fishermen have not been able to meet the needs of the canneries.

The Libyan-Guyanese Joint Trawling Venture

Libya and Guyana have agreed to set up a $5 million joint fishing company in which Guyana would control 51 percent of the shares. The company is being established within the framework of a bilateral cooperative agreement signed by the two countries in 1977. Each country will have three representatives on the Board of Directors including a Libyan as general manager and a Guyanese as Chairman of the Board. Final agreement on the joint venture was reached during talks between a two-man team from the Libyan Secretariat of Light Industries and Guyanese Government fishery officials.

The Board of Directors held its inaugural meeting in December 1980 in Guyana when questions on the size of the fishing fleet, extent of the work force, and site headquarters were being settled. Guyana has already been selected as the base of operations. The Board of Directors is reportedly considering the possibility of leasing four trawlers until a decision is reached on the purchase of vessels. The company was expected to become operational by mid-1981 when fishing trawlers and new equipment for the company were to be delivered.

Libya has announced the formation of several joint fishery ventures with African countries. In most cases actual fishing operations never resulted. In those instances when a company was actually established the Libyan participation was limited to capital participation. It is believed that political factors often motivate the Libyan Government in establishing these joint ventures. (Source: IFR-81/58.)

New Ghanaian Tuna Fishing Regulations

The Vice President of the Republic of Ghana, J.W.S. deGraft Johnson, announced the drafting of new tuna fishing regulations for foreign fishermen in November 1980. Ghana claims a 200-mile territorial sea and fishing zone.

Speaking in Accra at a welcoming ceremony for a new Ghanaian tuna vessel belonging to the Mankoadze Fisheries Company, the Vice President stated that the new regulations would require foreign tuna fishermen operating in Ghanaian-claimed waters to pay a licensing fee of $150 per gross-registered-ton for their vessels or give 10 percent of their catch to the Ghanaian Government. According to deGraft Johnson, prior to the new law foreign tuna fishermen had been charged a small fee based on the amount of tuna caught, which was only about 1 percent of the value of the catch. The new law also requires foreign tuna companies to enter into 50-50 joint ventures with Ghanaian companies with the understanding that the Ghanaian partners would eventually assume full ownership of the firm.

In his announcement, deGraft Johnson alleged that Korean (ROK) and Japanese tuna vessels based in Ghana had increased their catch from 6,000 metric tons (t) to over 30,000 t since 1973. The Vice President regretted that "while these foreign fishing companies derive commercial bounties from our waters, the inactivity of the Ghanaian fishing fleet forces the Government to spend $20 million annually from scarce foreign exchange resources to import canned fish, mostly from Japan."

[1]Additional details on Taiwan's tuna operations in Uruguay can be obtained by requesting IFR-81/34 from local NMFS Statistics and Market News Offices.

Ghana's tuna fishery, which includes both an artisanal and a commercial sector, is one of the most important in Africa. Ghana's 1979 tuna catch totaled about 17,500 t, an increase of 5,800 t over the previous year. The primary species caught in 1979 were little tuna (5,550 t), frigate and bullet tunas (4,400 t), and skipjack tuna (4,200 t). (Source: IFR-81/65.)

Thailand and PRC Form Joint Fishing Ventures

Several Thai fishing companies have been negotiating contracts for joint ventures with the Hainan Island Fisheries Department in southern China for access to the Beibuwan (Gulf of Tonkin) fishing area. Details of the deals provide an insight into how the People's Republic of China arranges joint fishing ventures and the profit margins foreign partners can expect.

Maha Nakorn Fishing and Cold Storage Co. of Thailand concluded one of the first China-Thai joint venture deals in November 1980. The contract is in three parts: Between Maha Nakorn and individual Thai trawlers[1]; between Maha Nakorn and the PRC; and between Maha Nakorn, PRC, and the trawler owners.

The individual fishing trawlers covered by this agreement must have at least 23 crew members, good equipment, engines with at least 450 horsepower and a 80-t hold. The Thai side pays for ice, fuel, and the food and salaries of the Thai crew. The Thais will also be responsible for maintenance of the vessels, including spare parts. Convertible foreign currency will be used to buy food, ice, fresh water, and fuel at local prices from the Chinese. China has set the minimum monthly wages for workers in the venture[2]: Captains, engineers, and supervisors, US$214 per month, and crew members, US$175 per month. The Chinese will provide a navigator, a radio operator, and a coordinator for each trawler, and provide special berths for the vessels while they are in port to speed operations.

The contract requires that the Thai side sell "small fish" to China at a local price and sell "big fish" in Hong Kong. The definition of small and big is somewhat vague. The Thai partner pays three types of duties on fishery products sold in China: A special fee of 1.25 percent of the value of the catch as assessed at the unloading berth; 5 percent of the profit from local sales to cover insurance and paperwork; and a 16 percent local tax on the profit. Payments will be made and the books audited monthly; any income that the Thais receive from the Chinese side will be paid in coupons which will have to be used in China. The Thais are subject to a 3 percent Chinese export tax for fish sold in Hong Kong. The tax is based on the Hong Kong value of the fish. China receives 30 percent of the profits on the Hong Kong sales.

Maha Nakorn company officials are reportedly not totally satisfied with the terms of the venture, but decided to take a risk because otherwise they would have no place to deploy their vessels. Other Thai companies negotiating with the Chinese on similar joint venture contracts say that the 30 percent division of the profits is too high and want a 20-80 split. Nonetheless, Thai interest in fishing in Chinese waters is said to be growing, partly because of the failure of Thai companies to renegotiate similar agreements with Bangladesh, but also because many of the Thai trawlers are idled due to high diesel prices in Thailand. Thailand became one the the world's most important distant water fishing nations in the 1970's, but Thailand's catch plummeted from 2.2 million metric tons (t) in 1977 to 1.7 million t in 1979 after international fuel price increases and the extension of 200-mile fishing zones by neighboring countries. Preliminary reports for 1980 suggest that the catch has continued to decline.

China, like Bangladesh, may have some reservations about joint ventures with Thai companies. Thai companies which signed contracts with the Chinese after Maha Nakorn report that the Chinese are limiting initial joint venture contracts to six vessels and 6 months. Whether these restrictions relate to China's reservations about Thai joint ventures alone is uncertain. Recently, the Chinese Communist Party theoretical journal, *Hongqi (Red Flag)*, called for greater protection of China's aquatic resources and improved organization in the fishing industry. In any case, it does not appear that many fisheries joint ventures will be formed between China and foreign fishing companies in the near future. (Source: IFR-81/51.)

[1]Maha Nakorn does not operate its own trawlers, but rather coordinates the activites of individually owned vessels.

[2]The contract requires that wages be in Hong Kong dollars: Captains, engineers, and supervisors are to receive HK$1,100 monthly; and crew members, HK$700 plus a HK$200 food allowance.

Ecuadorean Shrimp Exports Increase

Ecuadorean companies set a new shrimp export record in 1980. Shipments (product weight) totaled 9,500 metric tons (t), a 50 percent increase over the 6,300 t exported during 1979. A total of 21 companies exported shrimp in 1980, five of them for the first time. Three companies (Empacadora Shayne, Empacadora Nacional, and Marfrut Export) accounted for nearly half of all 1980 shipments. Three companies (Camaronera C., Copesa, and Langostino C.) more than doubled their 1979 shrimp shipments (Table 1).

The increased exports have resulted mostly from the growing harvest of cultured shrimp which now accounts for over half of the entire Ecuadorean

Table 1.—Ecuador can shrimo exports (product weight in metric tons), 1979 and 1980.

Company	1979	1980	Percent change
Empacadora Shayne	1,451.0	1,833.7	+26
Empacadora Nacional	1,533.2	1,814.4	+18
Marfrut Export	523.8	991.1	+89
Codinasa	412.7	761.5	+85
Ipesa	584.2	730.6	+25
Copesa	296.4	666.6	+125
Pesquera Sta. Priscilla	211.4	407.1	+93
Frimar	237.0	384.4	+62
Langostino C.	175.4	355.2	+103
Camaronera C.	45.3	355.1	+684
Frigorifico el Oro	246.8	281.7	+14
Pesquero Capricornio	215.0	230.0	+6
Ecuadorian Sea Foods	196.4	228.8	+16
Exporklore		160.2	
Exportadora del Pacifico	65.1	99.5	+53
Songa	82.3	83.3	+1
Expromar	35.8	46.6	+30
Piscicola El Paraiso		32.4	
Langostino del Golfo		32.2	
Progalca		18.2	
Empacadora del Pacifico		5.2	+53
Total[1]	6,312.8	9,517.7	+51

[1]Totals may not agree due to rounding.

shrimp catch. The trawl fishermen have been reporting a declining catch since 1977 when a drought began which substantially reduced rainfall and lowered the volume of water flowing into Ecuadorean rivers. The reduced water volume means that a smaller quantity of nutrients is being transported by the rivers and that the salinity of the water in coastal estuaries has increased. Both factors have adversely affected shrimp stocks. (Source: IFR-81/63.)

The Fisheries of Benin

The People's Republic of Benin, with approximately 3 million inhabitants, is located between Togo and Nigeria. The coastal port city of Cotonou (population 175,000) is the chief business and fisheries center in the country. The Beninese economy is based on palm oil and palm oil processing, peanuts, cotton, and coffee. Major food crops include corn, cassava, yams, rice, sorghum, and millet. In addition, fish provides an important source of protein for the local population.

Benin's fish catch is taken primarily from lagoon and marine waters. The catch from both these fisheries has declined since 1972, when a coup d'etat brought Mathieu Kerecou and the Marxist Benin People's Revolutionary Party to power. The decline has been so severe that Benin, which formerly exported fish and fishery products to Europe and neighboring countries, has now become a net importer of fish.

Lagoon Fisheries

The lagoons and associated lakes and rivers of Benin normally provide about 80 percent of the locally consumed fish and crustaceans. Fishing is done by traditional means and is usually marketed in villages along the coast. The fisheries sector provides employment to some 50,000 fishermen.

The yield of the lagoon fishery has dropped from 18,000 metric tons (t) in 1960 to between only 4,000 and 5,000 t per year in 1980. This decline is due to both mismanagement and natural causes, including salt water intrusion, sedimentation, and the entry of a species of the mollusk teredo (shipworm) which attacks the hulls of wooden boats. In addition, some species have been overfished and fishermen continue to use wasteful fishing techniques. There is no evidence that the Government is taking any effective action to solve these problems or otherwise reverse the decline in production, although the Government has sought foreign aid for some fish culture projects.

Marine Fisheries

Until the November 1972 coup, private French, Italian, and Greek fishing companies based in Cotonou operated in the offshore waters and provided the Government with considerable taxes and export earnings. However, fearing nationalization, these companies gradually abandoned operations in Benin. As a result, Benin's marine catch dropped sharply (Table 1). In 1975, a parastatal enterprise was created to replace them (Sonapeche: Societe Nationale d'Armement et de Peche). Sonapeche, like most of the other Beninese parastatal enterprises, is functioning poorly if at all.

Table 1.—Benin's marine fisheries catch, 1972-1978[1].

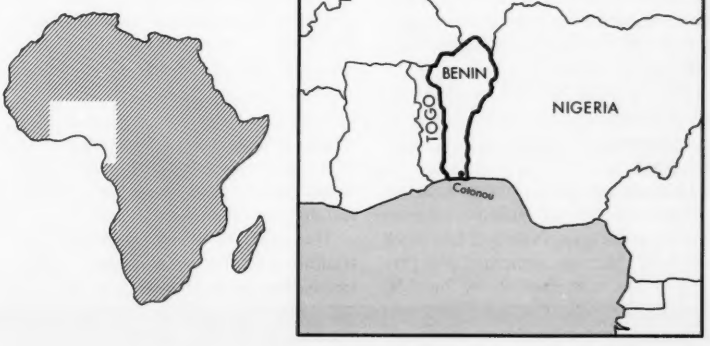
Year	Quantity (t)	Year	Quantity (t)
1972	6,592	1976	1,214
1973	5,073	1977	948
1974	3,822	1978	729
1975	2,028		

[1]Source: U.S. Embassy, Cotonou. FAO catch data for Benin in the "Yearbook of Fishery Statistics" differ from the information presented here.

Joint Ventures and Foreign Fishing

A Beninese-Libyan joint venture, financed by Libya, was launched in 1979; however, the company has yet to begin operating and shows little prospect of doing so soon. A Greek company is known to be operating off the Benin coast, sending substantial amounts of frozen shrimp and other products to Europe. The United Nations Development Program is financing a project which is designed to improve the catch of the artisanal fishermen living along the coast, but this is not expected to have a major impact on national production figures. (Source: IFR-81/47.

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR) or Language Services Biweekly (LSB) reports produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.



Fishery Technology: Reviews and Advances

To herald 50 years of research and development, the Torry Research Station hosted an international conference on fish science and technology from 23 to 27 July 1979. The result is a huge 528-page (8¼x11¾-inch) tome entitled "**Advances in Fish Science and Technology.**" Edited by J. J. Connell, Director of the Aberdeen, Scotland, facility, it is published by Fishing News Books Ltd., 1 Long Garden Walk, Farnham, Surrey, England.

The first, or "Review Section", of the volume (p. 1-191) is devoted to 18 articles exploring the past, present, and future of both fish technology and fish science by recognized authorities. The second section (p. 192-507) is given to 62 papers describing recent advances and ideas.

In the review segment on fish technology, K. C. Lucas has discussed how changes in fish resources and extended fishery jurisdictions are affecting the fishery managment, development, and utilization. G. H. O. Furgess then traces the origins and influence of scientific and technical ideas on fish industries. G. C. Eddie reviewed past, present, and future fish handling methods while Poul Hanses did the same for fish preservation methods. In addition, Maynard O. Steinberg delivered a comprehensive statistical analysis of world fish utilization. Methods of marketing, distribution, and quality assurance are discussed by E. Graham Bligh.

The second part, fishery science, contains reviews on sensory and nonsensory assessment of fish by J. J. Connell and J. M. Shewan, structure and proteins of fish and shellfish by June N. Olley and Z. E. Sikorski, fish lipids by R. G. Ackman and R. Hardy, other organic and inorganic componenents by S. Ikeda, fish in human and animal nutrition by Kenneth J. Carpenter, biological factors affecting processing and utilization by R. Malcolm Love, microbiology in fishery science by J. Liston, physical properties and processes by A. C. Jason and M. Kent, and the application of engineering science to fish preservation by M. R. Hewitt and S. Forbes Pearson.

Section II, "Recent advances," is divided into 14 parts, leading off with six papers in minced fish developments. "Process and new product investigations" presents papers on canned fish behavior during storage, technology of Spanish canned mussels, H_2O_2 to whiten fish flesh, auto-oxidation of sardine oil, and others. Another section discusses recent advances in fish smoking; yet another presents papers on chilled and frozen storage of hakes, cod, and scad.

Krill developments are treated in six papers (quality and shelf-life, composition and properties of krill fingers, economics of krill fishing, krill sausage, and nutritional experiments).

Two papers deal with fish technology and its transfer while six discuss fish by-products. Seasonal changes in blue whiting, stored mackerel, and lipids of manid, *Pimelodus clarias*, are reported. Another five papers deal with methods of quality assessment while eight protein studies are presented. Other papers deal with microbiology, low molecular weight compounds, water in fish, and histology of blue whiting.

The immense volume with 400 illustrations and 279 tables, covers a wide range of subjects in presenting a valuable account of the current status of fisheries technology. Indexed the hardbound edition is available from the publisher for £39.50 plus £3.90 postage and packing.

Pollution and Physiology of Marine Organisms

"Marine Pollution: Functional Responses," edited by Winona B. Vernberg, Frederick P. Thurberg, Anthony Calabrese, and F. John Vernberg, has been published by Academic Press, Inc., 111 Fifth Ave., New York, NY 10003.

Part I, "Petroleum Hydrocarbons," begins with a review of these chemicals in the marine environment. Other articles discuss the detoxification system in polychaete worms, temperatures and respiratory rates of pink salmon fry exposed to hydrocarbons, effect of naphthaline on Bering Sea sculpins, free amino acid content of *Macoma inquinata* exposed to oil, and differential sensitivity of fish embroyonic stages to oil.

Part II, "Metals," includes papers on toxic cations and marine biota, heavy metals and regeneration in estuarine fish and crabs, hematological effects of long-term mercury exposure on winter flounder, bivalve mollusks in heavy metal pollution research, cytopathological effects of $CuSO_4$ of the chemoreceptors of blue crab, and copper and cadmium induced changes in molluscan gill tissue.

Part III, "Pesticides and PCB's," presents an overview of pesticides on the estuarine environment, effect of PCB's on fatty acid composition of phospholipids in sculpins, parathion metabolism by intertidal invertebrates, and PCP toxicity to crustaceans.

Part IV, "Multiple Factor Interactions," contains papers on the effect of Dimilin on stone and blue crab larvae, seasonal modulation of thermal acclimation and behavioral thermoregulation in aquatic animals, multiple factor interactions and stress in coastal systems, seasonal effects of chlorine produced oxidants on the American oyster, and beyond the LC_{50}: an opinion about research activities and needs concerning physiological effects of pollutants in the environment.

Typed for rapid reproduction, the 454-page hardbound volume sells for $26.00.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

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Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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Authors must double-check all literature cited; they alone are responsible for its accuracy.

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All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

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Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., BIN C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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